THE 2ND NATIONAL COMMUNICATIONS REPORT

of St. Christopher and Nevis under the United Nations Framework Convention on Climate Change (UNFCCC)

Droiterre Inc. and Associates,
Legal & Environmental Consultants

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Droiterre Inc. and Associates,
Legal & Environmental Consultants
Suite 9, "Fenshaw", Pine Plantation Road,
St. Michael, Barbados W.I
Tel: 246-429-5120/246-233-6448
Fax: 246-429-9394
droiterreinc@caribsurf.com

Prepared by:

Mr. Derrick Oderson	Consultant
Dr. Leonard Nurse	Consultant
Dr. John Chalery	Consultant
Mr. Kishan Kumarsingh	Technical & Scientific Advisor

Foreward

Climate change is globally recognized as a major environmental and economic issue that poses unprecedented threats to mankind and ecosystems.

Honourable Eugene Hamilton
Minister of Environment

Although St. Kitts and Nevis contributes minimal greenhouse emission, it is expected to be severely affected by the impacts of climate change. These impacts include increasing temperatures, changes in precipitation patterns that can lead to flood in some areas and drought in other areas, an increase in storm intensity and rising sea levels. As a result of these projected impacts, critical sectors such as water, health, tourism, agriculture and coastal infrastructure will continue to be affected if these impacts are not minimized.

St. Kitts and Nevis strives to promote a sustainable economy that is resilient to the impacts of climate change. The preparation of the Second National Communication does not only allow us to meet our obligations under the Convention but it also allows us to assess our current activities that are geared towards addressing climate change. It incorporates areas that addresses the greenhouse gas inventory and the vulnerability and adaptation chapter. Recommended actions to address the impacts of climate change are also incorporated in the communication.

The Government of St. Kitts and Nevis wishes to express profound gratitude to the Global Environment Facility and the United Nations Development Programme for supporting the preparation of the Second National Communication.

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Chapter 1 National Circumstances

1.1 Geography and History

The twin island Federation of Saint Christopher (hereafter, St. Kitts) and Nevis is a state composed of two islands of the Lesser Antilles in the Eastern Caribbean Sea. Saint Kitts is located at latitude $17^0$15' north and longitude $62^0$45' west and Nevis is located two miles (3 km) to the south-east, at 17^0 10' north and longitude $62^0$35' west. Their combined area is 104 square miles (269 square kilometres). The capital of St Kitts is Basseterre.

Two miles apart, Saint Kitts and Nevis are in the northern part of the Leeward Islands, approximately two hundred fifty miles (402 kilometers) southeast of Puerto Rico. Saint Kitts, the larger island, is twenty-three miles (thirty-seven kilometers) in its greatest length, with an area of sixty-eight square miles (176.8 square kilometers). Nevis is thirty-six square miles (93.6 square kilometers) in area and is thus the smaller island in the federation. The island of Nevis is almost circular in length and the main town Charleston is located on the west coast.

Figure 1 Location of St Kitts and Nevis

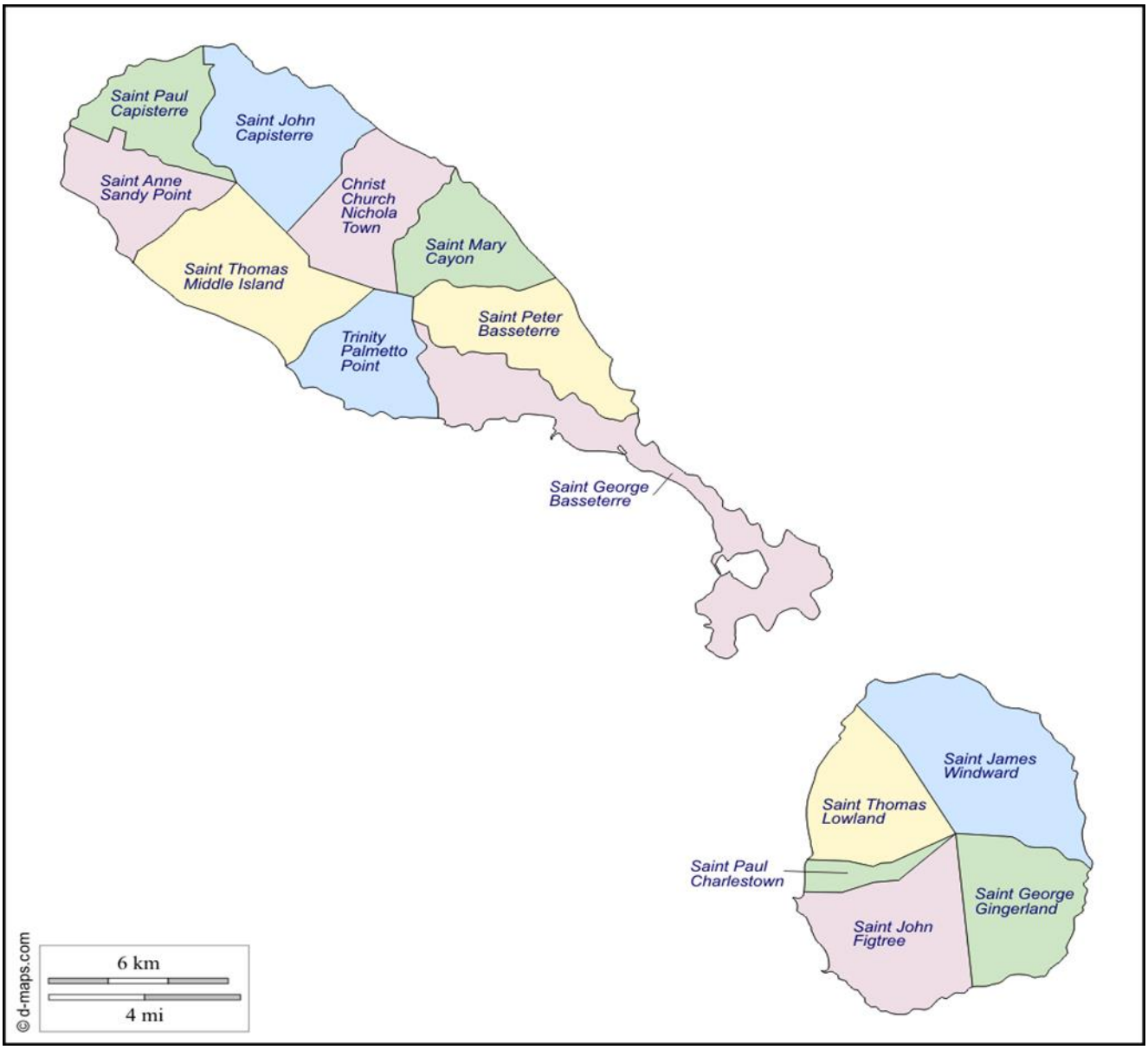
The islands are the summits of a submerged mountain range that forms the eastern boundary of the Caribbean Tectonic Plate (MOE, 2001). The physical landscape of Saint Kitts is characterized by three volcanic centres and ranges. The first is the central northwest range, dominated by Mt. Liamuiga, which rises with a pronounced crater to 1,156 meters (3,792 ft.). It is the highest peak in Saint Kitts and Nevis. The middle range is dominated by Verchild's mountain at 975 m, but otherwise consists of a number of irregular peaks. The southeast range has a number of irregular peaks with the highest at 900 m. The slopes of the latter two ranges are steeper and shorter on the leeward coast and the land near the coast is typically flat or moderately sloped; and hence the site of most development (MOSD, 2007). The slopes are cut by deep gullies or ghauts that act as the primary drainage channels (MOE, 2001), but they are

almost entirely dry for most of the year. Only the relatively large Wingfield and Cayon rivers flow almost to the sea for much of the wettest part of the year (DOE, 2001).

Figure 2 –Saint Kitts and Nevis

The coastline of Saint Kitts is dominated by cliffs, which are up to 30m in height. The beaches are often narrow black sand beaches, with pebbles and boulders at the foot. There are exceptions in the northwest where the beaches are wider, black sand beaches. There are long stretches of fine yellow sand beaches from Conaree to the southeast of the island (MOSD, 2007). The coastal and marine ecosystems in Saint Kitts include coral reefs, seagrass beds, mangroves and salt ponds. The most extensive mangrove habitat occurs in the south eastern peninsula along with the seagrass beds. Coral reefs are generally found along the southwest coast between Nag's Head and the southern end of Basseterre Bay, on the northwest coast between Sandy Point and Dieppe Bay, on the east coast between Conaree and Friar's Bay and on the southeast coast adjacent to the Narrows (MOSD, 2007).

Figure 3-Saint Kitts and Nevis-Political



Saint Kitts like other islands in the Caribbean has had much of its virgin forest cleared. While the peaks are still covered with some forest they do not show virgin forest characteristics. In general the forested areas in St. Kitts are increasing (Poverty Research Unit, 2006). On the lower slopes, particularly to the north, there is secondary growth (tropical woodland and fruits) on abandoned farmland that was once used for sugar cane and higher slopes provide short grass used for livestock grazing.

The lowlands are intensely used for development or farming and in the past the increasing demand for agricultural land resulted in many small farmers clearing forested land in the upper slopes

resulting in soil erosion, and pollution of streams, rivers and coastal waters (MOE, 2001). Hawksbill and green sea turtles are found around the entire coast and a large number of resident and migratory birds depend on the mangrove and pond communities for feeding and nesting (MOSD, 2007).

Nevis is volcanically active with fumaroles and hot springs (GFDRR, 2010). The highest point on Nevis is the central Nevis Peak (985 m) with Windy Hill (309 m), Saddle Hill (381 m) and Butlers Mountain (478 m) helping to define a north-northwest to south-southeast spine across the island (MOSD, 2007).

The land in Nevis is typically flat near the coast with sandy beaches, fresh water lagoons, rocky shores and cliffs. The beaches and lagoons (sourced from either mountain run-off or springs) are mostly found on the leeward coast with a 4 km stretch of beach between Charlestown and Cades Bay. The rocky shores and cliffs are found on the south and east coasts. Other important coastal ecosystems (in addition to the freshwater lagoons) include coral reefs and seagrass beds (MOSD, 2007).

Surface water drains in a radial pattern from Nevis Peak to the ocean through ten (10) major drainage basins (DOE, 2001). Almost all of these drainage channels are dry for large periods of the year, flowing mostly after heavy rainfall. The Bath Stream is the only exception, flowing year-round to the sea from springs less than 1.6 km inland (DOE, 2001).

Similar to Saint Kitts, Nevis has also been cleared of virgin forest at one time or another and although the peaks in Nevis are still covered they do not show virgin forest (Poverty Research Unit, 2006). Lower slopes have secondary growth on abandoned farmland and the lowlands are intensely used for development or farming (MOSD, 2007). Much of the land on Nevis is cultivated by rural farmers growing vegetables and coconuts and there is a large coconut forest on the west side (Poverty Research Unit, 2006).

St. Kitts was inhabited by the Amerindian people called Arawaks. The Arawaks entered the Caribbean from South America about two thousand years ago and by AD 1500 had occupied all of the islands of the Caribbean as far north as The Bahamas and as far west a Cuba. They were followed at a much later date by a more war like people called the Caribs (Dyde 2008).

The Carib Indians called the island of St. Kitts “Liamuiga” which means fertile land. Christopher Columbus sailed past St. Kitts on his second voyage on 13th November 1493. St. Kitts was named San Jorge and Nevis was named St. Martin. The names were later changed by Spanish sailors to what they are today and by the early sixteenth century the names San Cristobal, St. Christopher and Nevis, remained Spanish colonies for over a century, however they were never really settled by the Spanish colonizers, as they were more interested in the Greater Antilles of the Caribbean and Central America. St. Christopher and Nevis also had a sizeable Carib population. During the late sixteenth century St. Christopher and Nevis became extremely popular with English, Dutch and French born sea raiders.

In 1620 Ralph Merifield and Thomas Warner applied for and received a Royal Patent to settle the Leeward Islands and establish a colony. King James 1st granted the patent, and on 28th January 1624, Thomas Warner arrived in St. Kitts with settlers. Thomas Warner found a quite sizeable Carib population under the leadership of Tegreman, a local Carib. The French also began to settle St. Kitts in 1625 and eventually the French and the British drove the Caribs out of St. Kitts. Warner and the French drew up a treaty in 1627 which divided the island of St. Kitts in two between the British and the French. On 29 September 1629 Warner was appointed sole governor of St. Christopher's for life (Cal. State Papers, Amer. and W. Indies, 1574–1660, p. 101). Nevis was eventually settled by Anthony Hilton in 1628, who moved from St. Kitts. The settlers cleared land in the area which is now known as Charlestown. Hilton eventually became the first Governor of Nevis. In 1671 St Kitts and Nevis, were part of the British Leeward Island colony, along with Montserrat and Antigua.

Tobacco was the major cash crop in St. Kitts and Nevis with production reaching its height in 1638. Cotton was also planted. Many indentured servants from Ireland were used as workers for the cultivation of the crops. In 1648, Dutch refugees introduced sugar cane into the Caribbean. Sugar cane became the dominant crop, and this introduced the plantation society with slaves being imported from West Africa, to work on the plantations. Between 1675 and 1730, Nevis was the headquarters for the slave trade for the Leeward Islands, with approximately 6,000-7,000 enslaved West Africans passing through en-route to other islands each year. The Royal African Company brought all its ships through Nevis (Hubbard, Vincent K. (2002). Swords, Ships & Sugar: History of Nevis. Corvallis, Oregon)

With the departure of the French from St. Kitts, after the signing of the Treaty of Utrecht in 1713, considerable amounts of land became available for sugar cultivation and large sugar plantations were established using slave labour. Within eleven years of the Treaty of Utrecht out of a total population of 13,000, more than 10,000 were slaves. Fifty years later there were less than 2000, whites and over 20,000 slaves. The white population in Nevis which was 3500, in 1660, by 1710 had fallen to about 1300, while the slave population was approaching 6000. Sugar cultivation using slaves from Africa dominated St. Kitts and Nevis.

During 1700's and 1800's there were many wars between the colonial powers in the regions and the islands of St. Kitts and Nevis were often under attack and occupied by the French and the Spanish. Slavery and the production of sugar continued to dominate St. Kitts and Nevis. In the late 1700's and early 1800's slavery became increasingly unpopular. In 1807 the British parliament abolished the African slave trade in the British Empire by 1808, and the Emancipation Act of 1833, ended slavery by August 1834. The act however set up a system of apprenticeship, which required all former slaves to work on the plantation for 40.5 hours a week. The apprenticeship system which was abolished in 1838.

The Leeward Island colonies were administered by a Governor-in-Chief or a Governor General who from 1698 lived in Antigua. St Kitts and Nevis was under the control of a Lieutenant Governor who governed through a legislature consisting of a Council and an Assembly. The

members of the assembly were often well to do planters and merchants. In 1825, Anguilla was placed under the administrative control of St. Kitts, while the union of St. Kitts and Nevis took place in 1883, with the enlargement of the legislative council of St Kitts and the abolition of that in Nevis. In 1937 five places of the legislative council were reserved for elected representatives, three from St. Kitts and one each from Nevis and Anguilla.

In 1935 there were riots in St. Kitts. These riots were part of the wider social unrest in the British West Indies. These riots were caused by general social injustices, poor pay, unemployment and bad working conditions. The riots in the region led the British to appoint a Royal Commission led by Lord Moyne to investigate the social and economic conditions in all of the West Indies territories and to make recommendations. The Commission recognized the need for labour reform in the region and recognized the need to have legalized trade unions. In 1940 the St. Kitts-Nevis Trade and Labour Union was formed. Robert Bradshaw became President of the Union in 1944 and eventually also led the St. Kitts –Nevis Labour Party, which had grown out of the union.

Universal adult suffrage, along with a new constitution in 1952, provided improvements in the way St. Kitts, Nevis and Anguilla were administered. The St. Kitts-Nevis Labour party won all of the 5 seats on the legislative council in the first election under the new system. In 1956 three elective members of the executive council assumed responsibility as Ministers for matters such as trade, public works, communications and social services. The position of Chief Minister was established four years later. In 1956 Robert Bradshaw was Minister of Trade and Production for St. Kitts-Nevis-Anguilla. Paul Southwell served as the Chief Minister of Saint Kitts and Nevis from January 1960-July 1966. Bradshaw was elected to the post of Minister of Finance for the short lived West Indian Federation from 1958 to 1962.

With the failure of the Federation, in 1967, the British granted associated state status to St. Kitts-Nevis- Anguilla, with full internal self-government, and the establishment of a Senate and a representative house. In 1966 Bradshaw became Chief Minister, and in 1967 the first Premier of St. Kitts-Nevis-Anguilla. Anguilla however did not agree to be part of the new state of St. Kitts-Nevis-Anguilla and eventually a rebellion broke out in Anguilla, which eventually led to Anguilla severing any status with St. Kitts and Nevis, and returning to colonial status.

Bradshaw continued to have discussions with the British on full independence. Bradshaw died in 1978, and in 1980, the St Kitts –Nevis Labour party were ousted from office by the Peoples Action Movement. Anguilla seceded in 1980, and the Federation of St. Kitts and Nevis gained independence on Sept. 19, 1983 under Kennedy Simmonds as Prime Minister. Simmonds lead the government until 1995 when his Party was ousted by the St Kitts –Nevis Labour Party, under the leadership of Denzil Douglas. In 2015, the Labour government was ousted by a Unity Government comprising of the People's Labour Party, The Peoples Action Movement and the Concerned Citizens Movement.

Table 1- Chief Minister, Premiers and Prime Ministers of St. Kitts and Nevis

Chief Ministers of St Kitts and Nevis (1960–67)		
	Time in Office	**Political Party**
Paul Southwell	January 1960-July 1966	St Kitts and Nevis Labour Party
Robert Bradshaw	July 1966- February 1967	St Kitts and Nevis Labour Party
Premiers of St Kitts and Nevis (1967–83)		
Robert Bradshaw	February 1967-May 1978	St Kitts and Nevis Labour Party
Paul Southwell	May 1978- May 1979	St Kitts and Nevis Labour Party
Lee Moore	May 1979- February 1980	St Kitts and Nevis Labour Party
Kennedy Simmonds	February 1980-September 1983	People's Action Movement
Prime Ministers of St Kitts and Nevis (1983–present)		
Kennedy Simmonds	September 1983- July 1995	People's Action Movement
Denzil Douglas	July 1995-February 2015	St Kitts and Nevis Labour Party
Timothy Harris	February 2015 -present	People's Labour Party

1.2 Climate

As with most Caribbean islands, the climate of St. Kitts and Nevis is heavily influenced by the marine environment. The average temperature at Basseterre is 27.8°C and seasonal and diurnal variations in temperature are small (typically 3-5°C). Only at higher elevations do temperatures drop below 17°C (MOSD, 2007).

St. Kitts and Nevis has a wet season between August and September, when relative humidity is typically 78%. The drier months occur between January and April, when relative humidity drops to approximately 70% (MOSD, 2007). Rainfall is strongly related to altitude, with the central mountain range receiving an annual average of 2,500 mm to 4,000 mm (Climate Lab, n.d.) and coastal areas receiving a more modest annual average of 1,016 mm (MOSD, 2007). The situation is quite different along the south eastern peninsula, where mean annual precipitation varies from 990 mm on the peaks to 864 mm at Cockleshell Bay (MOSD, 2007). Annual average rainfall on Nevis is about 1170 mm (DOE, 2001).

Given the location of St. Kitts and Nevis in the north east trade winds, the prevailing wind direction swings seasonally between northeast and southeast, with mean speeds ranging from 8.7 km/h in November to 14.6 km/h in July. Higher speeds are experienced during the dry months of January and March and during the hurricane season (June to November), when low pressure systems and tropical disturbances pass through the area (MOSD, 2007). Some of the major hurricanes that have affected St. Kitts include Hurricane Hugo (1989), Hurricanes Luis and Marilyn (1995), Hurricane Georges (1998), Hurricane Omar (2008), Hurricane Earl (2010) Tropical Storm Emily (2011), Tropical Storm Rafael (2012) and Tropical Storm Gonzalo (2014). Further information on the climate of St. Kitts and Nevis can be found in the chapter on vulnerability and adaptation.

Table 2 Tropical Storms and Hurricanes impacting St. Kitts and Nevis 1950-2014

Year	Hurricane/ Tropical Storm	Year	Hurricane/ Tropical Storm
Aug 1950	Hurricane BAKER	Jul 1996	Hurricane BERTHA
Sep 1950	Hurricane DOG	Sep 1998	Hurricane GEORGES
Sep 1953	Tropical Storm EDNA	Oct 1999	Hurricane JOSE
Jan 1954	Hurricane ALICE	Nov 1999	Hurricane LENNY
Aug 1956	Hurricane BETSY	Aug 2000	Hurricane DEBBY
Aug 1959	Tropical Storm EDITH	Sep 2004	Tropical storm JEANNE
Sep 1960	Hurricane DONNA	Dec 2007	Hurricane OLGA
Oct 1963	Tropical Storm HELENA	Oct 2008	Hurricane OMAR
Jul 1979	Tropical Storm CLAUDETTE	3 Sep 2009	Hurricane ERIKA
Sep 1979	Tropical Storm FREDERIC	Aug 2010	Hurricane EARL
Sep 1981	Tropical Storm GERT	Sept 2010	Hurricane IGOR
Sep 1989	Hurricane HUGO	Aug 2011	Tropical Storm EMILY
Aug 1995	Tropical Storm IRIS	Oct 2012	Hurricane RAFAEL
Sep 1995	Hurricane LUIS	Oct 2014	Hurricane GONZOLO
Sep 1995	Hurricane MARILYN		

Box 1-Impact of tropical cyclones in St. Kitts and Nevis

The social and economic impacts of hurricanes and tropical storms in St. Kitts and Nevis can be devastating. A direct hit by a Hurricane is not necessary to cause significant damage and economic impacts. In October 2008: Nevis was brushed with the edge of Hurricane Omar. Along with other establishments, The Four Seasons resort was forced to close to undergo repairs. Hence with respect to damage to a single property, Hurricane Omar caused the loss of between 600-800 direct and indirect jobs for over 2 years. The Four Seasons resort is the major employer in Nevis. The resort reopened on 15 December 2010.

Hurricane Georges hit St. Kitts and Nevis in September 1998, with winds of up to 115mph. Georges caused serious damages to St. Kitts and Nevis, with up to 85% of the housing stock damaged. In total there was over US$400 million worth of damage, with 170% of GDP worth in losses.

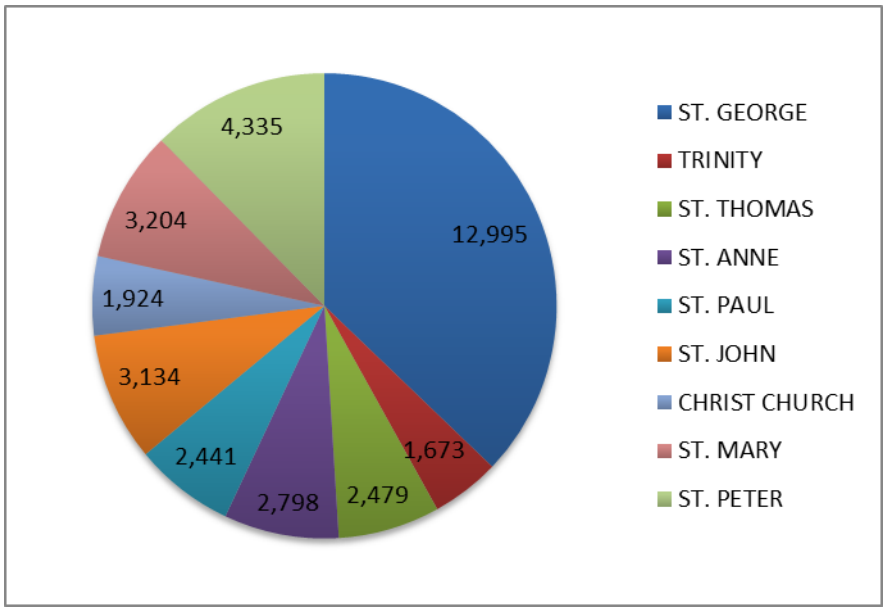
Table 3 Selected Impact of Hurricanes in St. Kitts and Nevis

Date of Event	Number of People Affected	Deaths	Economic Impacts (US $millions)
September 1989 Hurricane Hugo	1,300	1	46
September 1995 Hurricane Luis	1,800	0	197
September 1998 Hurricane Georges	10,000	5	400
November 1999 Hurricane Lenny	1,180	0	41.4

1.3 Population and Economy

According to preliminary data from the 2011 census the population of the Federation of St. Kitts and Nevis is 46,398 (34,983 in St Kitts and 11,415 in Nevis).

Figure 4 Population by Parish of St. Kitts and Nevis



The gender distribution in St. Kitts and Nevis is almost equal (see Table 4). The population of St. Kitts and Nevis is approximately 95% black, with 5% mixed, white and Indo-Pakistani 5%. The crude birth rate in 2007 was 13.63 per 1000, while the crude death rate was 7.03 per 1000. The infant mortality rate was 20.29 per 1000 in 2007. Life expectancy for males was 68.37 and 74.32 for females in 2004.

The major urban areas are Basseterre and Charlestown. In St. Kitts, while the population is concentrated in capital and surrounding suburban areas, a considerable portion of the population is located in coastal areas, with many villages located along coastal roads. Nevis follows a similar pattern to St Kitts with the population being concentrated in and around Charlestown. Many of the villages in Nevis are located along the islands main road which mirror the coast of the island. The location of the population centres on the coast enhances the vulnerability of St. Kitts and Nevis to the impacts of climate change.

Figure 5 St Kitts and Nevis population 1871 to 2011

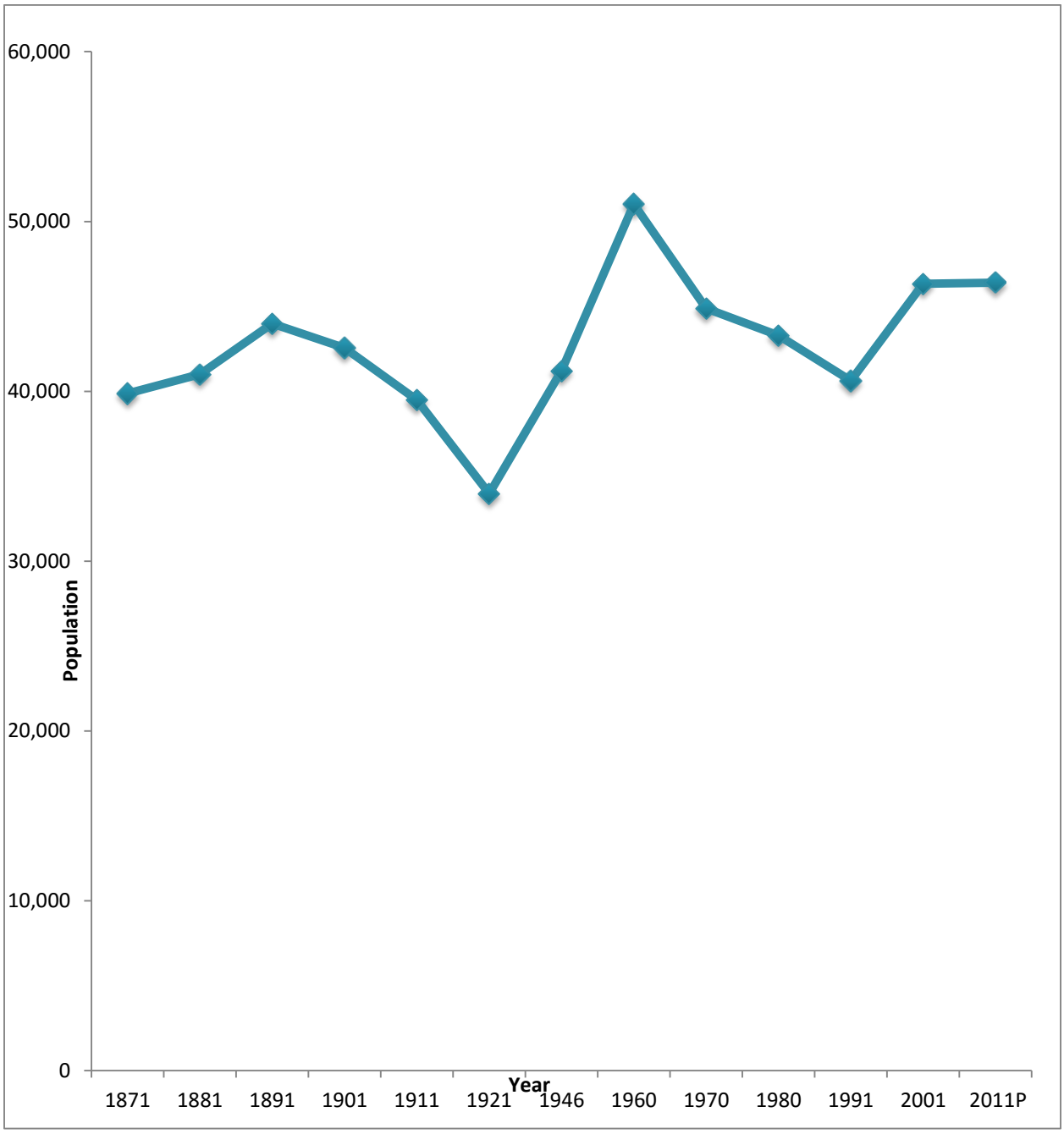


Figure 6 Nevis Population 1871 to 2011

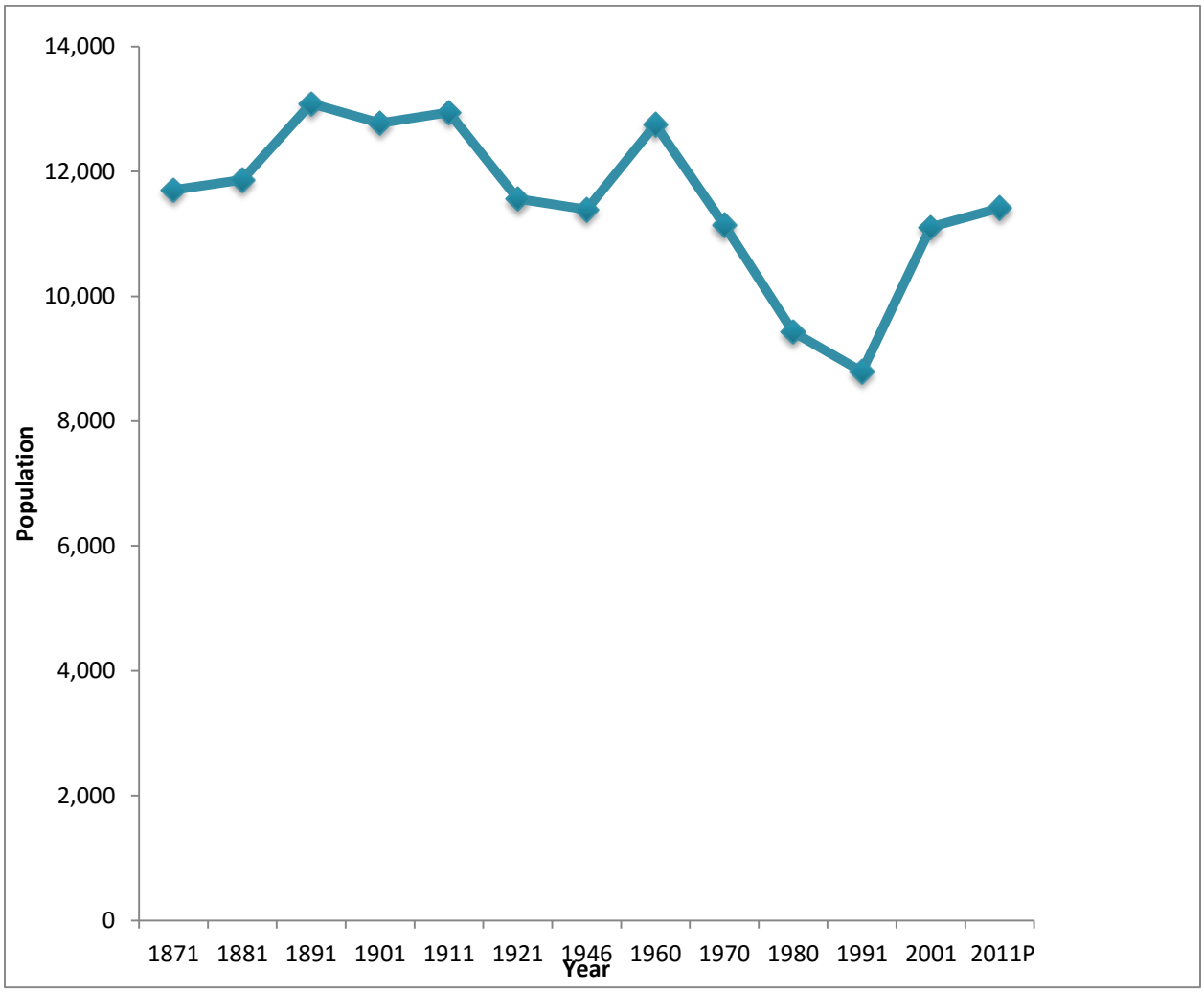


Figure 7 St. Kitts Population 1911-2011

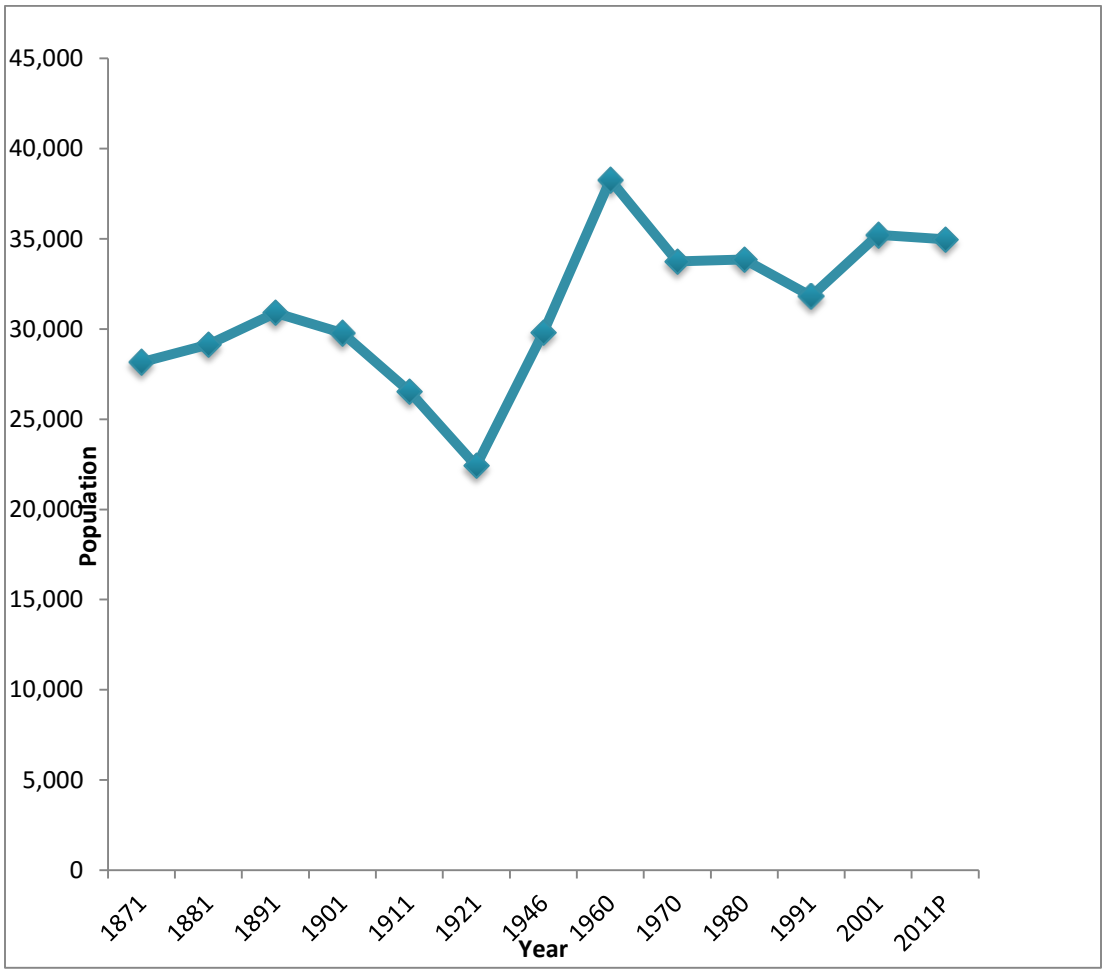


Table 4 -Population Distribution by Gender 2011

	Male	Female
St. Kitts	**17,236**	**17,747**
Nevis	**5,604**	**5,811**
Total	**22,840**	**23,558**

Table 5 –Selected Indicators

Indicator	Year -2013
Crude Birth Rate (1000)	11.79
Crude Death Rate (1000)	7.5
Infant Mortality Rate (per 1000)	14.63

Table 6- GDP by Economic Activity Current Prices[1]					
	Year				
Sector	**2009**	**2010**	**2011**	**2012**	**2013**
Agriculture, Livestock and Forestry	15.86	18.80	19.54	18.04	20.61
Crops	9.18	11.49	12.26	11.35	13.72
Sugar	-	-	-	-	-
Other Crops	9.18	11.49	12.26	11.35	13.72
Livestock	6.12	6.74	6.70	6.11	6.29
Forestry	0.56	0.57	0.57	0.58	0.59
Fishing	7.60	7.87	9.69	9.12	8.93
Mining & Quarrying	3.07	2.25	1.44	1.44	2.37
Manufacturing	150.64	173.78	186.40	213.46	193.42
Sugar	-	-	-	-	-
Other	150.64	173.78	186.40	213.46	193.42
Electricity & Water	25.41	26.13	26.23	30.09	29.92
Electricity	16.23	16.85	17.76	17.95	17.87
Water	9.18	9.28	8.47	12.13	12.05
Construction	277.57	235.25	217.63	195.81	222.91
Wholesale & Retail Trade	138.85	138.89	135.80	142.89	152.33
Hotels & Restaurants	85.24	96.57	102.83	105.72	111.20
Hotels	82.34	93.08	98.98	101.77	107.05
Restaurants	2.90	3.50	3.85	3.95	4.15
Transport, Storage and Communications	186.23	203.75	224.18	224.09	236.22
Transport and Storage	107.58	118.61	137.47	137.00	147.96
Road Transport	64.00	73.92	85.48	89.46	99.43
Sea Transport	0.66	0.69	0.70	0.69	0.71
Air Transport	0.95	1.07	1.11	1.25	1.28
Supporting and Auxiliary Transport Activities	41.97	42.92	50.18	45.59	46.54
Communications	78.65	85.14	86.70	87.10	88.27
Financial Intermediation	204.02	126.11	120.61	113.82	118.00

Banks	134.43	81.23	75.79	70.30	72.80
Insurance	28.48	23.74	23.98	24.20	25.17
Activities Auxiliary to Financial Intermediation	41.11	21.14	20.84	19.33	20.02
Real Estate, Renting and Business Activities	284.19	290.35	285.07	283.80	297.19
Owner Occupied Dwellings	121.89	124.49	126.47	128.13	132.68
Real Estate Activities	104.75	110.68	114.95	117.20	121.37
Renting of Machinery and Equipment	2.99	3.95	2.64	2.24	2.33
Computer and Related Activities	21.04	17.75	6.33	4.92	5.82
Business Services	33.51	33.48	34.69	31.32	35.00
Public Administration, Defence & Compulsory Social Security	148.30	153.12	163.19	166.25	193.35
Education	85.67	90.49	90.09	91.19	98.64
Public	60.73	59.67	60.43	61.10	64.34
Private	24.94	30.82	29.66	30.10	34.30
Health and Social Work	46.68	43.65	45.10	45.72	49.74
Public	35.27	33.76	33.97	34.22	36.04
Private	11.41	9.88	11.12	11.50	13.70
Other Community, Social & Personal Services	46.96	43.61	45.41	46.28	50.28
Activities of Private Households as Employers	5.95	5.27	5.55	5.29	5.76
Less: FISIM	24.52	17.50	16.74	16.02	15.82
GVA in Basic Prices	1,687.73	1,638.39	1,662.01	1,677.02	1,775.06
Growth Rate	**(1.64)**	**(2.92)**	**1.44**	**0.90**	**5.85**
Plus: Product Taxes	228.33	231.24	303.73	299.17	315.29
Less: Subsidies	2.06	-	-	-	-
GDP in Market Prices	1,914.01	1,869.64	1,965.74	1,976.18	2,090.34
Growth Rate	**(3.51)**	**(2.32)**	**5.14**	**0.53**	**5.78**

[1] Data from http://www.eccb-centralbank.org/Statistics/index.asp

For many years the economy of St. Kitts and Nevis was based on the sugar industry. This has now changed. As a result of changes in the international trading regime, along with an end to preferential access to markets the sugar industry was closed in 2005. Table (6) shows the gross domestic product by economic activity for the period 2009-2013.

Preliminary data suggest that economic activity in St Kitts and Nevis rose in 2013 following a contraction in 2012. Real GDP is estimated to have risen by 2.0 per cent in 2013 in contrast to a decline of 0.9 per cent in the previous year. This turnaround resulted largely from a positive value added contribution of the construction sector, which reversed a four year decline and continued positive growth in the tourism industry, as well as, the wholesale and retail trade sectors. Consumer prices increased by 0.4 per cent, on an end of period basis. (Annual Economic and Financial Review 2013)

The fiscal operations of the Federal Government are anticipated to improve due to reforms geared towards improving the tax administration system. These revenue gains are expected to outpace increases in current expenditure. Inflationary pressures are anticipated to be minimal on account of recent trends and the absence of either internal or external mitigating circumstances. (Annual Economic and Financial Review 2013)

The International Monetary Fund (2014) noted that the fiscal position of the central government of St Kitts and Nevis has further strengthened, with continued and sustained budgetary discipline. The fiscal balance has improved from a deficit of 7.8 percent of GDP in 2010 to a projected surplus of 10.6 percent of GDP in 2013, and the primary balance strengthened from a deficit of 0.8 percent to a surplus of 15.5 percent of GDP.

The tourism industry is now the main economic activity in St. Kitts and Nevis. The direct contribution of travel & tourism to GDP in St. Kitts and Nevis was XCD129.5mn (6.2% of total GDP) in 2013, and is forecast to rise by 6.3% pa, from 2014-2024, to XCD256.0mn (8.6% of total GDP) in 2024 Tourism is also a major employer in St. Kitts and Nevis. Travel & Tourism generated 1,500 jobs directly in 2013 (6.1% of total employment). This includes employment by hotels, travel agents, airlines and other passenger transportation services (excluding commuter services). It also includes, for example, the activities of the restaurant and leisure industries directly supported by tourists (World Travel & Tourism Council 2014).

Figure 8 Contribution of Travel and Tourism to the Economy of St. Kitts and Nevis (WTTC 2014)

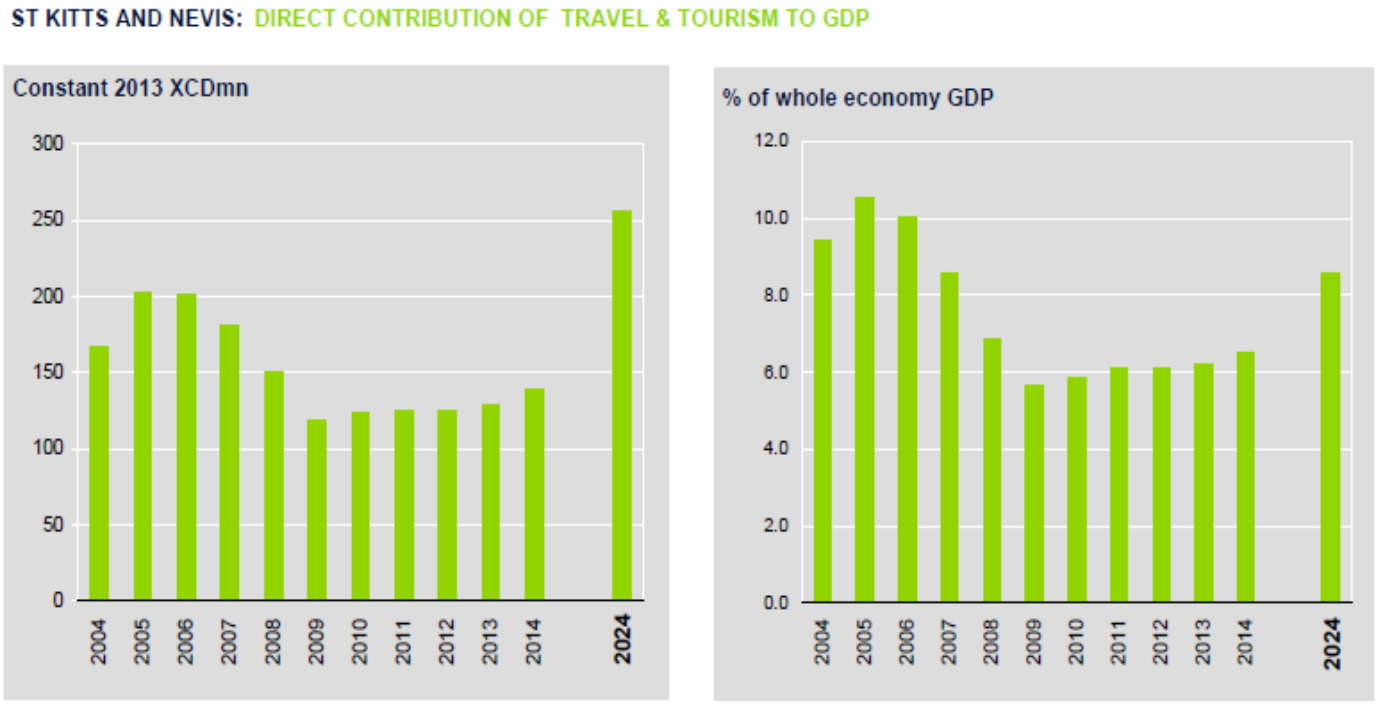


Table 7 St Kitts and Nevis Total Visitors 2009-2013

Year	Number of Visitors
2009	547,561
2010	621,275
2011	715,250
2012	635,426
2013	690,340

1.4 Institutional and Legislative Framework for Sustainable Development[2]

1.4.1 Institutional Framework

In St Kitts and Nevis there has been a long history of addressing various aspects of sustainable development, particularly soil and water conservation. This history is associated with the sugar industry, given that land management including conservation activities, were integrated into the management of overall operations of the sugar estates. The Ministry of Sustainable Development is primarily responsible for the management of sustainable development in St. Kitts and Nevis.

The Ministry of Sustainable of Development was established in 2005 and became responsible the lands and surveys functions of the Ministry of Agriculture and Housing and the environment management portfolio from the Ministry of Health. The Ministry of Sustainable Development is composed of the following departmental components:

i. Administration,
ii. Economic Affairs and Public Sector Investment Programme,
iii. Physical Planning and Environment,
iv. Lands and Surveys and
v. Statistics

The Department of the Environment (DOE) was established in 1996 in the Ministry of Health and Environment. With the establishment of the Ministry of Sustainable Development in 2005 to lead the design and implementation of the countries development agenda and to allow St. Kitts and Nevis to meet its international obligations to various bi-lateral and multilateral economic and environmental agreements, the Department of the Environment was merged with the Physical Planning Division to create the Department of Physical Planning and the Environment (DPPE) for St. Kitts.

In 2015, after the general elections, the Department of Environment was placed in the Ministry of Agriculture, Marine Resources, Cooperatives, Environment and Human Settlement. The DOE functions as the lead agency for environmental management. As lead agency for environment, the DOE functions as the focal point in St Kitts and Nevis for the United Nations Framework on Climate Change (UNFCCC), the United Nations Convention of Biological Diversity (UNCBD) and the United Nations Convention to Combat Desertification UNCCD.

The Department of Lands and Surveys (St. Kitts) (DOLS) is responsible for the design, survey and implementation of residential land subdivision schemes. The DOLS works closely with the Development Control Planning Board (DCPB), the Department of Physical Planning and the Department of Environment and other relevant public sector institutions to rationalize land use and land development decisions.

[2] The section utilizes the information in; Islands planning services (2012), Stocktaking Report for United Nations Conference on Sustainable Development (Rio+20), National Preparatory Process, St. Kitts and Nevis

The DCPB is responsible for the review and determination of all building and development planning applications in St. Kitts. Additionally, the DCPB is responsible for land use zoning, review of environmental impact assessments and the design and implementation of development plans and broader national policy instruments such as the National Physical Development Plan (NPDP) (2005).

The NPDP provides a general framework that targets sustainable development in the context of land use planning. The purpose of the NPDP is to identify appropriate physical planning and land use strategies that allow for sustainable exploitation of the natural resource base and to direct the use of public sector and private industry resources for planned and orderly development. The DCPB addresses the broad sustainable development areas of:

i. Agriculture and rural development,
ii. Environmental protection,
iii. Water resource management,
iv. Land use planning,
v. Climate change adaptation, and
vi. Biological diversity conservation.

The Department of Economic Affairs and Public Sector Investment Programme is the main contact and coordinating office in the MSD for local, regional and international projects, and for lending and donor agencies such as the Caribbean Development Bank (CDB); Organization of American States (OAS); United Nations Development Programme (UNDP); United Nations Environment Programme (UNEP); the Global Environmental Fund (GEF); World Bank; and the European Union (EU).

This department prepares and manages the government's Public Sector Investment Programme (PSIP) through close collaboration with line ministries and statutory corporations. The PSIP directs the preparation of the capital budget and assists in ensuring a holistic approach to inter-ministerial and inter-departmental programming, so as to avoid duplicity. Nevis has its own Department of Physical Planning, National Resources and the Environment (DPPNRE) and it is responsible for land use planning, land conservation, and environmental management.

In 2005 the DPPNRE prepared a draft Physical Development Plan, which proposed land to be earmarked for various land use types including environmental conservation areas. The approval of that plan is still pending. Generally, the DPPNRE works closely with the DOE on St. Kitts with regard to the meeting country obligations under the key MEAs and other physical planning, development and environmental initiatives.

The Water Services Department (WSD) is responsible for the identification, upkeep and protection of water supply sources on St. Kitts. The WSD works in close collaboration with the DPPE. The Department of Agriculture (DOA) develops policies and programmes as it relates to agriculture. The DOA is responsible for a range of services related to agriculture and rural development in both St. Kitts and Nevis. Some of these include: soil sampling and analysis, soil conservation, forestry, water conservation and integrated pest management. The Public Works Department (PWD) oversees the design of new and maintenance of existing public infrastructure, including roads, drainage, bridges, and culverts

The Saint Christopher National Trust (SCNT) and the Nevis Historical and Conservation Society (NHCS) are civil society organizations that are involved in sustainable development decisions and matters affecting built heritage and conservation in St. Kitts and Nevis. The SCNT was founded in 2009 with the goal of preserving the national heritage of St. Kitts. The Trust evolved from the St. Christopher Heritage Society which was incorporated as a private company in 1994. The main objective of the SCNT is to promote the protection, conservation, interpretation and enhancement of the natural environment of St. Kitts, including its animals and plant life.

The NHCS was established in 1980 to conserve the natural, cultural, and historic resources of the island and adjacent marine areas. The society is a non-profit organization managed by an executive board. Since its inception the NHCS has instituted projects and policies designed not only to preserve Nevis' unique history and environment, but also to make that heritage accessible and intelligible to locals and visitors

The National Housing Corporation and the Nevis Housing and Land Development Corporation and the Solid Waste Management Corporation play a role in sustainable development in St. Kitts and Nevis. The National Housing Corporation on St. Kitts and the Nevis Housing and Land Development Corporation on Nevis is responsible for the public supply of affordable shelter accommodation and related infrastructure, while the Solid Waste Management Corporation is a statutory authority with the responsibility of developing solid waste management facilities for storage, collection, treatment and disposal of solid waste.

1.4.2 Legislative and Regulatory Framework

While there is no specific legislation addressing climate change or sustainable development there are a number of legislative and regulatory instruments that have direct and indirect linkages to sustainable development in St. Kitts and Nevis. These include:

i. National Conservation and Environmental Protection Act, 1987
ii. Development Control and Planning Act, 2000.
iii. Nevis Development Control and Planning Ordinance 2005
iv. Solid Waste Management Corporation Act
v. National Housing Corporation Act
vi. Whitegate Development Corporation Act, No. 15 of 1999
vii. Forestry Ordinance 1904

viii. Water Courses Ordinance 41/56
ix. Public Health Act No. 22 of 1969
x. Pesticide and Toxic Chemicals Control Act 1999
xi. Agricultural Development Act 1973
xii. St. Kitts-Nevis Building Regulations, Code and Guidelines (No.7 of 2000) and
xiii. Substances that Deplete the Ozone Layer (Control) Regulations (No. 06 of 2004)

The National Conservation and Environmental Protection Act (NCEPA) provides the legislative authority for the management and development of natural and historic resources in St. Kitts and Nevis. The NCEPA outlines a framework for the declaration of sensitive ecological and historic sites as protected areas.

Areas chosen as protected areas under this piece of legislation must have the following purposes and objectives:

- to preserve the biological diversity of wild flora and fauna that may be endemic, threatened or of special concern, and the land and marine habitats upon which the survival of these species depends;
- to protect selected examples of representative or unique biological communities, both on land and on marine areas;
- to sustain natural areas important for the protection and maintenance of life support systems, and basic ecological processes including water recharge and soil regeneration; and
- to protect selected natural sites and scenic beauty of special scientific, ecological, historical or educational value, including sites that are already degraded and need protection for restoration or sites that may become degraded if not protected.

The purposes and objectives of NCEPA have linkages to climate change adaptation and other aspects of sustainable development.

The Development Control and Planning Act, No. 14 of 2000 (DCPA) makes provisions for the orderly and progressive development of land in both urban and rural areas of St. Kitts. It complements the NCEPA in that it provides for the protection of the environment and improvement of associated amenities. With regard to land use planning and management, the Act sets out the framework for the grant of development permission and for the design and implementation of a National Physical Development Plan (NPDP) to direct spatial development through time. Planning and development control functions include but are not limited to the following:

- review of building and development applications;
- zoning;
- review of EIAs;
- Design and implementation of development plans;

Similar to the NCEPA the DCPA contains provisions that establish linkages to climate change adaptation.

The Nevis Development Control and Planning Ordinance 2005 provides the legislative framework for the Nevis Island Administration to prepare physical development plans that would guide the development and management of land use on the island. Also, it provides for the exercise of development control, including building activities. The Ordinance has a similar scope to the DCPA on St. Kitts as it makes provisions also for the following:

- review of building and development applications;
- land use zoning;
- review of EIAs;
- design and implementation of development plans; and
- natural and heritage preservation;

The Water Courses and Water Works Ordinance (Cap 185 of 1956) establishes legislative and regulatory powers for the WSD on both islands to, regulate the supply of water to consumers, prevent waste, misuse and pollution of water and control sanitation of watersheds. It addresses issues of water supply and protection of watercourses. The management of watersheds in St Kitts and Nevis is shared between several agencies. These include the, Water Services Department; the Department of Physical Planning and Environment; the Department of Physical Planning Natural Resources and the Environment; and the Department of Agriculture

The St. Kitts-Nevis Building Regulations, Code and Guidelines (No.7 of 2000) (often referred to as the Building Code) provides the regulatory framework for the management of construction and built developments. The scope of the Code applies to the construction of new buildings and structures, alterations, renovations, remodelling, demolitions, removal, relocation, maintenance and occupancy of existing buildings. The DCPA is the parent legislation that guides the implementation of the Code. The Building Code has linkages to climate change adaptation and resilience.

The Substances that Deplete the Ozone Layer (Control) Regulations (No. 06 of 2004) shows the commitment of St. Kitts and Nevis to meet its requirements under the Montreal Protocol. The Montreal Protocol is an international agreement that seeks to control the production and consumption of certain ozone-depleting substances. This regulation has linkages to climate change mitigation.

As with many islands in the Caribbean the risk of accelerated land degradation as an environmental problem has become more apparent in St Kitts and Nevis following the 2005 closure of the sugar industry. This has led to the implementation of the Sustainable Land Management Plan (SLMP). The SLMP developed a set of draft sustainable land management which naturally have links to climate change adaptation.

1.4.3 Policies and Plans

As a result of being party to multilateral environmental agreements (MEAs) St Kitts and Nevis has prepared a number of national implementation plans and policies. St. Kitts and Nevis ratified The Montreal Protocol on Substances that deplete the Ozone Layer was in 1992. A national ozone unit at the DPPE was established under the institutional strengthening component.

St. Kitts and Nevis ratified the United Nations Convention to Combat Desertification (UNCCD) on June 30 1997. The UNCCD National Action Plan (NAP) was prepared in 2007. The NAP identifies the factors that have contributed to land degradation and physical measures required to combat land degradation and mitigate the effects of drought.

The Conservation on Biological Diversity (CBD) was ratified by St. Kitts and Nevis in 1993. The St. Kitts and Nevis Biodiversity Strategy and Action Plan (NBSAP) prepared in 2004 provides a report on strategies for conservation of the biological resources of St. Kitts and Nevis, through the specification of goals and objectives, defining the current known range and status of biodiversity, describing the probable sources of biodiversity losses, analysis of gaps and identification of actions that can address the gaps. The second NBSAP was prepared in December 2009

The National Physical Development Plan (NPDP) (2005) for St. Kitts also highlights a general framework that targets sustainable development in the context of land use planning. The purpose of the NPDP is to identify appropriate physical planning and land use strategies that allow for sustainable exploitation of the natural resource base and to direct the use of public sector and private industry resources for planned and orderly development.

A Physical Development Plan has been prepared for Nevis. The plan includes policies and guidelines for sustainable development and seeks to guide location of housing, industry, parks/conservation areas, hotel and tourism development with regards to land suitability and other physical and environmental attributes.

The National Adaptation Strategy (NAS) was adopted for the period 2006-2013 in response to the closure of the sugar cane industry in 2005. It identifies environmental management as an integral component of overall national development. The focus areas of the NAS include (a) the maintenance of macro-economic stability to reduce vulnerability and facilitate investment; (b) improvement competitiveness in the production and export of goods and services; (c) the adoption of social policies to support economic development and protect the most vulnerable; (d) the promotion of a sustainable development agenda; (e) restructuring and transformation of the economy; (f) the development of appropriate legal and regulatory frameworks; and, (g) the efficient provision of public goods (such as education and health).

There is also a National Environmental Management Strategy (NEMS) which seeks to:

- reduce current and potential environmental degradation particularly in the area of solid waste and marine pollution;

- reduce the adverse environmental effects of current and future economic development;
- educate and raise awareness on current and potential environmental issues;
- research and promote the available environmentally friendly alternate technologies in the energy and water sector; and
- protect and conserve those threatened biodiversity.

The Agricultural Strategic Plan (2005-2009) was developed in response to the new European Union (EU) sugar regime and closure of the sugar industry. The plan aims to expand significantly the development of non-sugar agriculture and increase its contribution to the country's Gross Domestic Product (GDP). The plan proposes a market-led approach toward increasing productivity, with an emphasis on crop and livestock production.

A National Capacity Self-Assessment (NCSA) was financed by the GEF to identify and analyze priorities and needs at the country level for capacity development related to the implementation of the UNCBD, UNFCCC, and the UNCCD. A number of crosscutting issues related to the implementation of these three conventions were identified in the NCSA report. These include: national policy, legal and regulatory framework; monitoring and enforcement; awareness and exchange of information; institutional management and performance; Individual skills and motivation; information management and reporting; mobilization of science in support of decision-making; financial resources; and incentive systems and market instruments. The cross cutting capacity needs identified in the NCSA stocktaking exercise were used as the priority elements for attention in the Capacity Development Action Plan (CDAP).

In 2001 a Natural Hazard Management and Mitigation Policy was developed for St Kitts and Nevis. The purpose of the policy was to provide proactive approaches for reducing vulnerability to environmental hazards by enhancing capacity for mitigation and engendering a culture of adopting mitigation measures. The policy sought to:

- Foster an environment supportive of resilient building and land use planning practices that were aligned with the principles of sustainable development.
- Encourage effective coordination among key stakeholders involved in national development.
- Increase community consciousness and commitment to carry out disaster mitigation and environmental risk reduction practices.

For the most part, the policy has been implemented with a moderate degree of success. Generally, natural hazard considerations have been factored into the national planning process. Natural Hazard Impact Assessment (NHIA) is now included in the Environmental Impact Assessment framework. Additionally, the Revised St. Kitts- Nevis Building Code makes provisions for improved building practices.

References

Annual Economic and Financial Review (2013), Eastern Caribbean Development Bank

Calendar of State Papers Colonial, America and West Indies, Volume 1, 1574-1660. Her Majesty's Stationery Office, London, 1860.

DOE. (2001). National Report on Integrating the Management of Watersheds and Coastal Areas in St. Kitts and Nevis. Basseterre: Department of Environment, Ministry of Health and Environment, Government of St. Christopher (St. Kitts) and Nevis

Dyde (2005.) Out of the Crowded Vagueness-A history of the islands of St. Kitts, Nevis and Anguilla, Mcmillan Education

Dyde (2008). St Kitts-Cradle of the Caribbean 4th Edition, Mcmillian Education.

GFDRR. (2010). Disaster Risk Management in Latin America and the Caribbean: GFDRR Notes (Saint Kitts and Nevis section). World Bank Global Facility for Disaster Risk Reduction.

International Monetary Fund (March 2014) Country Report No. 14/86; St. Kitts and Nevis 2014 article iv consultation and the seventh and eighth reviews under the stand-by arrangement and request for waivers of applicability and non-observance of performance criterion—staff report; press releases

Hubbard (2002). Swords, Ships and Sugar- History of Nevis, Premiere Editions International Inc.

Hubbard (2002). A History of St Kitts –The Sweet Trade, Macmillan Education.

Islands planning services (2012), Stocktaking Report for United Nations Conference on Sustainable Development (Rio+20), National Preparatory Process, St. Kitts and Nevis

MOE (2001). St. Kitts-Nevis Initial National Communication. Basseterre, St. Kitts-Nevis: Ministry of Environment, Government of St. Kitts Nevis**.**

MOSD. (2007). National Action Programme for Combating Desertification and Land Degradation: In the Context of the United Nations Convention To Combat Desertification. Basseterre: Department of Physical Planning and Environment, Ministry of Sustainable Development, Government of St. Kitts and Nevis.

Poverty Research Unit. (2006). Part 3: Overview of 3 OECS Islands: Dominica, St. Kitts & Nevis, and St. Lucia. Brighton, UK: Sussex University.

Simpson, M. C., Clarke, J. F., Scott, D. J., New, M., Karmalkar, A., Day, O. J., Taylor, M., Gossling, S., Wilson, M., Chadee, D., Stager, H., Waithe, R., Stewart, A., Georges, J., Hutchinson, N., Fields, N., Sim, R., Rutty, M., Matthews, L., and Charles, S. (2012). CARIBSAVE Climate Change Risk Atlas (CCCRA) - Nevis. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies

Simpson, M. C., Clarke, J. F., Scott, D. J., New, M., Karmalkar, A., Day, O. J., Taylor, M., Gossling, S., Wilson, M., Chadee, D., Stager, H., Waithe, R., Stewart, A., Georges, J., Hutchinson, N., Fields, N., Sim, R., Rutty, M., Matthews, L., and Charles, S. (2012). CARIBSAVE Climate Change Risk Atlas (CCCRA) - St. Kitts. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies.

World Travel & Tourism Council (2014), Travel& Tourism Economic Impact 2014-St Kitts and Nevis

Chapter 2 The Greenhouse Gas (GHG) Inventory

The Greenhouse Gas (GHG) inventory for St Kitts and Nevis reports on the GHGs emissions and sinks for the period of analysis, 1998 to 2008. The Intergovernmental Panel on Climate Change (IPCC) Revised 1996 Guidelines for National Greenhouse Gas Inventories and the software, version 1.3.2 were used for the estimation of the GHGs emissions and sinks. The major GHG was Carbon Dioxide and the minor GHGs were methane, nitrous oxides, partially fluorinated hydrocarbons, non-methane volatile organic compounds, carbon monoxide, sulphur dioxide and nitrogen oxides. Data were provided by the Government of St. Kitts and Nevis and the FAO Statistics Division 2014.

For the purposes of the Second National Communication for St. Kitts and Nevis, the inventory was required to report on the following individual sectors: Energy, Industrial Processes and Product use, Agriculture, Land-use Change and Forestry, and Waste. However, due to the unavailability of data, this inventory reported only on emissions and sinks from the Energy, the Agriculture and Land-use Change and Forestry sectors. The IPCC default values for the carbon emission factors and fraction of carbon oxidised were used as there were no locally developed or applicable emissions factors. Additionally, only the reference approach outlined in the IPCC 1996 methodology was reported as sectoral data were unavailable.

The GHG inventory summaries the data source, the methodology, the results based on the interpretation of the reference approach of the emissions and sinks, and the associated uncertainties. In addition missing data and gaps were reported based on information from the St. Kitts and Nevis Initial National Communication.

2.1 General Overview

The main GHG emission for St Kitts and Nevis was carbon monoxide which was contributed by the agricultural sector from the residual crops. For 2003-2006 there were no available data for the cotton crop residue and as a result there were no CO related emissions. However, it is assumed that CO would have been the major contributor considering previous years. Secondly the burning of fossil fuels in the energy sector contributed to emitted carbon dioxide. The other GHGs emitted were the nitrous oxides, methane and nitrogen dioxide and the quantities for the associated years are shown in **Figure 1**. The forest removed approximately 137 Gg of carbon dioxide yearly.

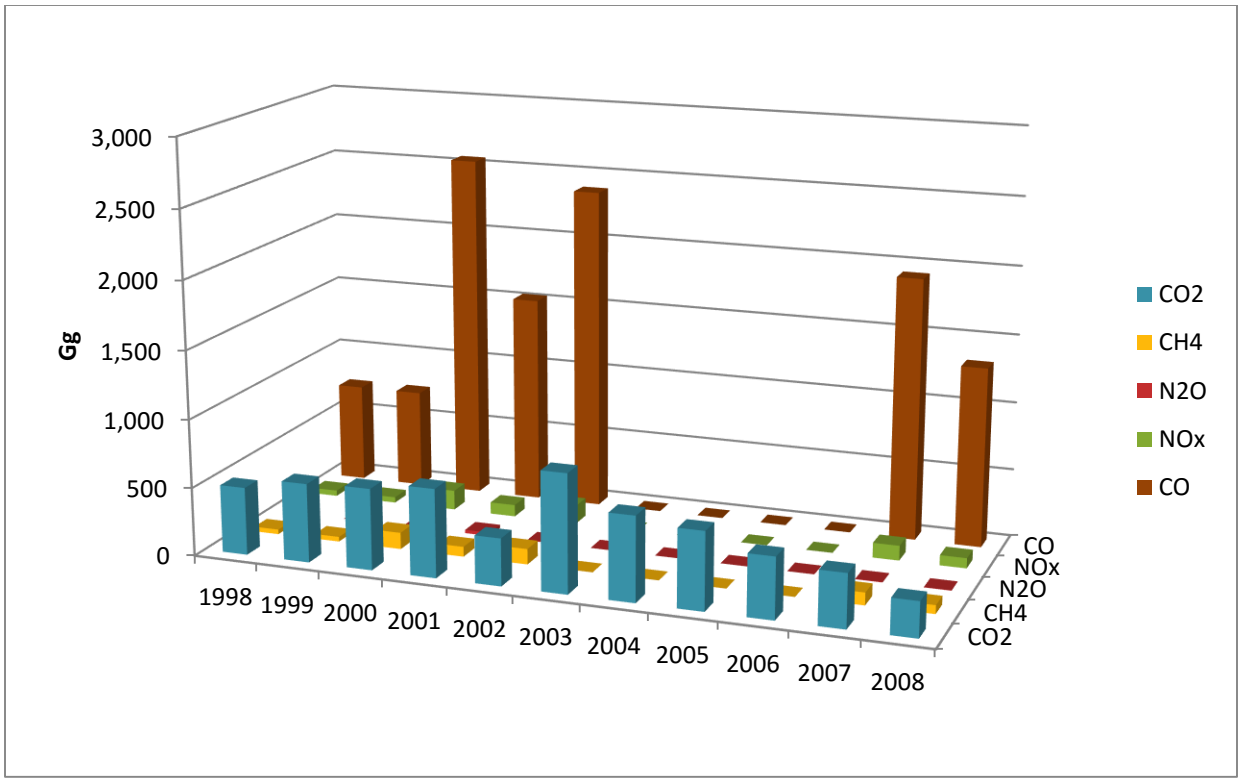


Figure 1 Summary of the total greenhouse gases emissions (Gg) for the period 1998-2008

2.2 The Energy Sector

Significantly, for the energy sector St Kitts and Nevis apparent consumption was based on fossil fuels imported for the purpose of electricity generation and transport. The consumption of the following primary fuels; gasoline, jet kerosene, other kerosene, gas/diesel oil, bitumen, lubricants and other oils, were responsible for the energy sector greenhouse gas emissions. No fugitive emissions were reported since there were no production of oil and gas.

The apparent consumption of the primary fuels was recorded in imperial gallons which was converted to the energy equivalent, Terajoules, using the conversion factors specific to the fuel consumed. The conversion factors were adopted from Converterin (2012). In order to calculate the carbon dioxide emissions from the apparent consumption of fuel the default IPCC emission factors and the IPCC carbon oxidation factors were used.

St Kitts and Nevis' Initial National Communication reported that in 1994 the carbon dioxide emissions were 76.64 Giga-grams (Gg). **Figure 2** illustrates the fluctuation of the carbon dioxide emission from the consumption of the fuel in the energy sector for the period 1998 to 2008, and indicates that in 2003 there was an emission of 862 Gg of CO_2 which was the highest CO_2 emissions for the period analysed. After 2003 the amount of emissions appeared to have decreased.

Gasoline and gas/diesel oil are the two main contributors of carbon dioxide emissions, approximately 30% and 60% respectively, as shown in Figure 3. The consumption of gasoline was mainly for transportation, and emissions generally increased from 1998 to 2007 while the majority gas/diesel oils which were consumed in the generation of electricity decreased slightly. The remaining 10% of carbon dioxide were as a result of the jet kerosene, other kerosene, lubricants and other oils.

There were no available sectoral data for the energy industries, manufacturing industries and construction, transportation and other sectors. Nevertheless it was assumed that the energy industries and transportation sectors would have been the major contributors given the use of the fuel in electricity generation and transportation. No data was supplied for the consumption of LPG.

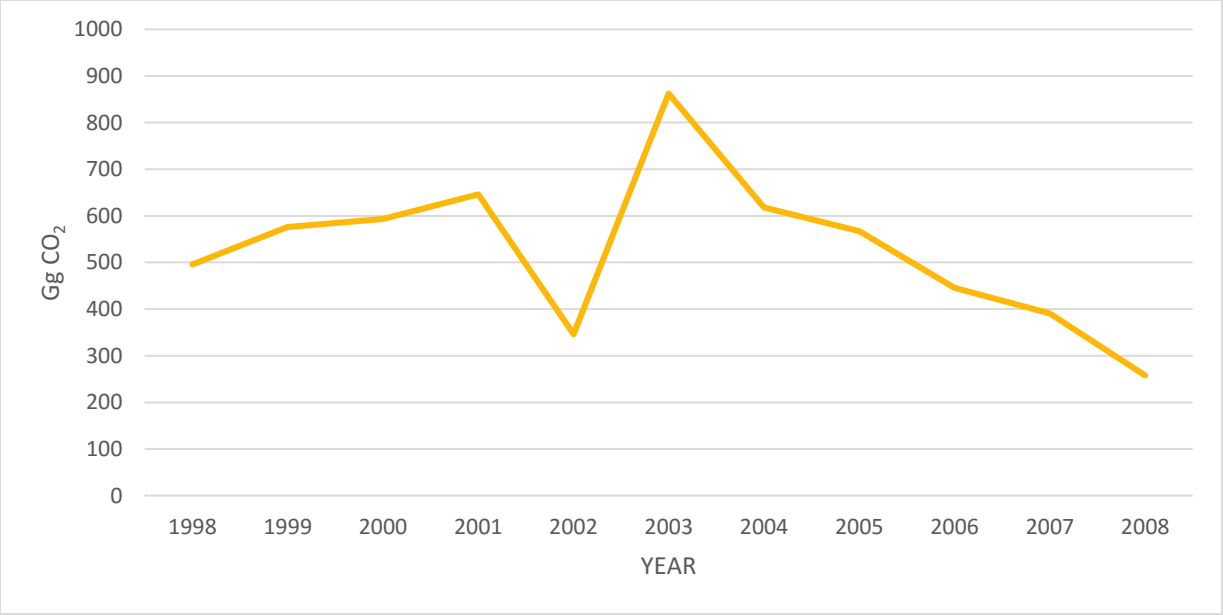


Figure 2 Carbon dioxide emissions (in Gg) for the energy sector based on the period 1998 to 2008.

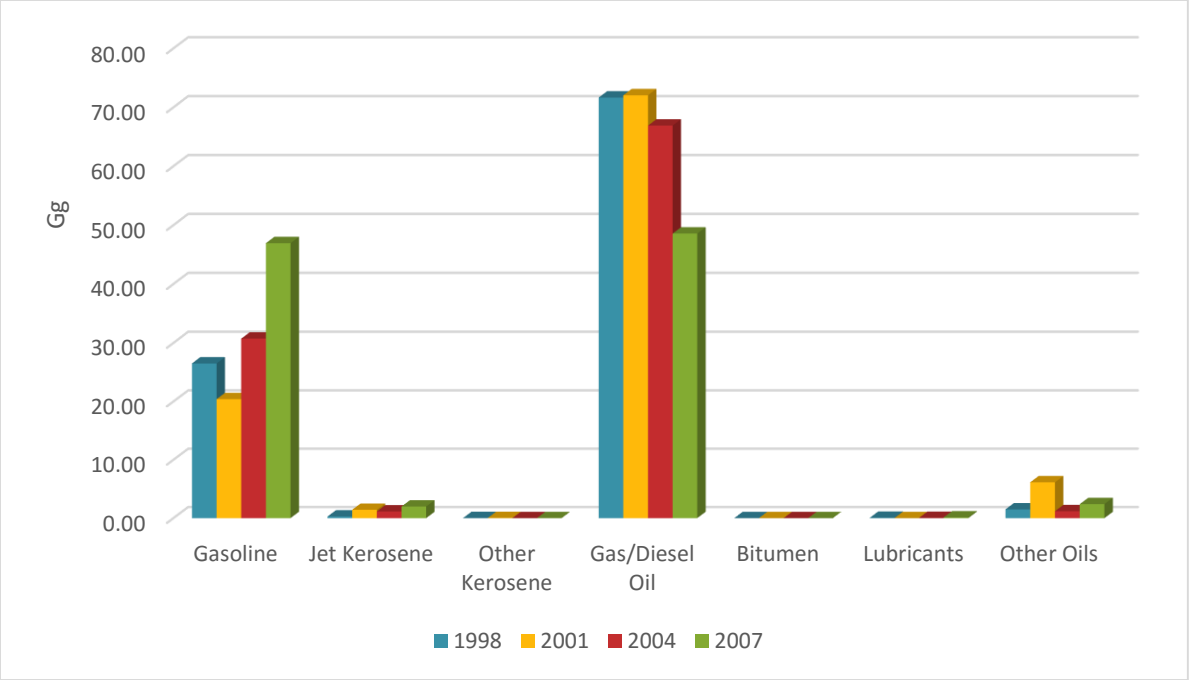


Figure 3 The CO_2 emissions from energy sources and the fuel combustion categories for the 1998, 2001, 2004 and 2007.

The uncertainties of the emissions reported however were low since the reported values were based on the reference report. Considering that the values were not available for St Kitts and Nevis the IPCC default values for the emission factors, net calorific values and the oxidising factors were used which may have introduced some uncertainty. However, this would be estimated to be low as the emission factors are not likely to vary and are fuel specific. Additional uncertainty may arise from the quality of the data supplied, which can be estimated to be also low as the data were Government-approved.

2.3 Industrial Processes and Product Use

No data were supplied for the Industrial Processes and Products Use sector.

St Kitts and Nevis Initial National Communication reported that the Federation does not have a strong Manufacturing or Industrial Sector. It was stated that in 1994, 1.18 Gg of non-methane volatile organic compounds (NMVOC) was emitted and was as a result of the asphalt road paving, alcoholic beverages and food production activities.

The missing data therefore are the alcoholic beverage type and the quantity produced, the type of food production and the quantity of food produced, for example bread, cakes, margarine, solid cooking fats, meat, fish and poultry, the quantity of road material used and the surface area paved.

2.4 Agriculture, Land-Use Change and Forestry

The agricultural sector emissions were based on data form the Agricultural Department and from estimates provided by the FAO Statistics Division 2014 for the period 1998 to 2008. St. Kitts and Nevis Initial National Communication greenhouse gas emissions for the agriculture sector was based on the following crops; sugarcane, vegetables, root and citrus crops, cotton and breadfruit, domestic animal population and the manure management. These activities contributed to 0.69 and 0.09 Gg of CH_4 and N_20 emissions respectively.

This report for the Agriculture Sector analysed the activities for cotton production, domestic animal population and the manure management due to limited data provided. Data were recorded in acres and the production of cotton and associated emissions were estimated using conversion factors and production data of cotton from Antigua and Barbuda (Maxime and Grant 2011), which is a reasonable application given the close geographical proximity of St. Kitts and Nevis and the similar climate.

From the raw data provided it was noted that in 1994 the area used for the production of cotton was 200 acres which was reduced to 15 acres in 1998 and increased to 34 acres in 2008. The CH_4, N_2O, NO_x and CO emissions from the agriculture sector are shown in **Figure 4**. Carbon monoxide was the major GHG contributor and was as a result of the burning of the crop residues. During 2003 to 2006 no data was available for the cotton production. It appears that the burning of the cotton residue was responsible for the CO. The other GHGs emitted from the agriculture sector in decreasing order were nitrous oxides, methane, and nitrogen dioxide also shown in **Figure 4**.

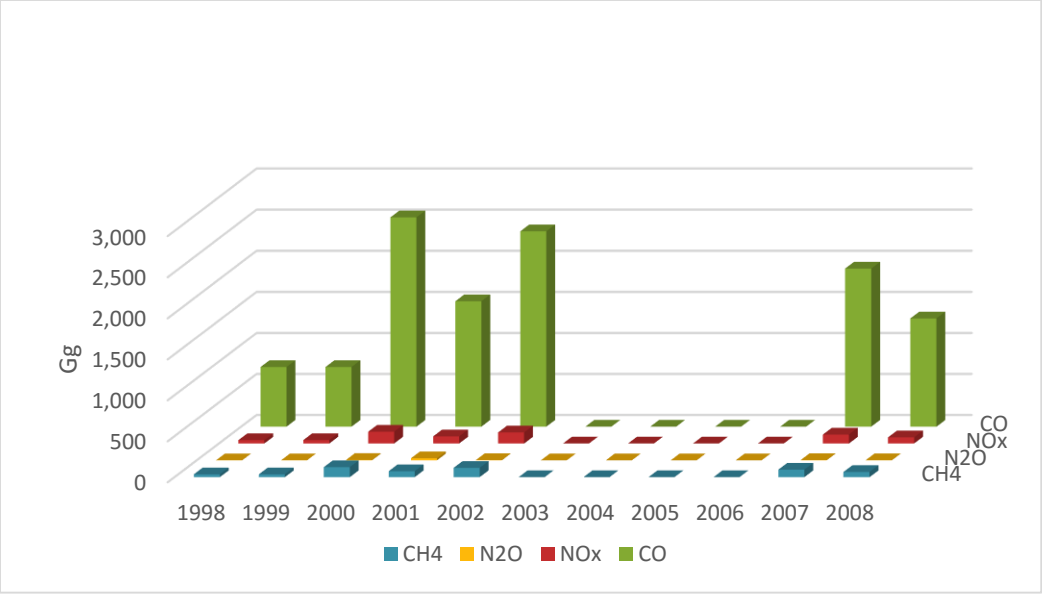


Figure 4: The greenhouse gases emissions for the agriculture sector for the period 1998 to 2008.

No data on Land-Use and Forestry was locally available and thus data from FAO Statistics Division 2014 was used to estimate the emissions/sinks from the sector. In the St. Kitts-Nevis Initial National Communication it was reported that the total forest acreage was 8.6 kilo hectares (kHa) which comprised of mixed softwoods, mixed hardwoods, other forests-moist, other forest-dry and other forest and shrubs. However, the FAO reported that 11 kHa out of the total 26 kHa was forested area in 1994 and there were no changes in 2008. In this second national communication it was assumed that the forested area was mixed with softwoods and hardwoods which provided an estimated sink of 137 Gg of CO_2.

The uncertainties of the estimated emissions and sinks from the agricultural and land-use and forestry sectors are as a result of the use of the default IPCC emissions factors. For the agriculture sector the Latin America regional default values, the IPCC carbon fraction of dry matter and the carbon fraction were adopted in this study. Another factor contributing to the uncertainty was the estimation of the production based on the area cultivated. For the land-use and forestry FAO data may have been over estimated since the initial communication reported less forest coverage compared with the FAO data which was utilized for this report.

2.5 Waste

No data were supplied for the waste sector.

In the initial national greenhouse gas inventory of St Kitts and Nevis, solid waste disposal on land and sewage were accountable for 2.1423 and 0.01 Gg the emissions of CH_4 and N_20, respectively. These emissions were noted to have originated from solid waste disposal on Land and indirect nitrous oxide emissions from human sewage.
The missing data for the waste sector are the total annual municipal solid waste disposal to solid waste disposal sites and the per capita protein consumption (kg\person\yr).

Recommendations

- It is highly recommended that measures be establish for a detailed data collection system. It is recommended to train personnel to gather St Kitts and Nevis data specific for future national inventories.
- In addition, data collection for sectoral data on fuel consumption in the energy sector would be critical in the identification of mitigation analyses in these sectors.
- It is urged to avoid missing data as discussed in the section above for each sector.

References

Converterin 2012. Gallon [UK] Of Kerosene Type Jet Fuel to Terajoule Converter. Accessed 5 June 2013. http://converterin.com/energy/gallon-uk-of-kerosene-type-jet-fuel-to-terajoule.html

Maxime and Grant 2011. Sea Island Cotton Production in Antigua and Barbuda. Accessed 5 July 2013. http://www.google.tt/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CC8QFjAB&url=http%3A%2F%2Fagricultureantiguabarbuda.com%2Fwp-content%2Fuploads%2F2011%2F01%2FSea_Island_Cotton_Production_in_Antigua_and_Barbuda1.ppt&ei=bQPkUeuvFqL64APszYC4Cg&usg=AFQjCNEn0qk3Dbo9-yMDJNPr1bTeCjX5uw&bvm=bv.48705608,d.dmg

Chapter 3 Vulnerability and Adaptation in St Kitts and Nevis

3.1 Introduction

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) highlighted the intrinsic and fundamental vulnerability of small island developing states to climate change. St Kitts and Nevis as a typical small island state exhibits the characteristics which make the twin island state especially vulnerable, these include limited size, proneness to natural hazards, and external shock. Further, the recently released Fifth Assessment Report has noted that "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" (IPCC-AR5 WGI, 2014: 4). Moreover, the chapter 'Small Islands' in the IPCC Working Group II AR5 Report reconfirmed the conclusion of previous assessments that the world's small islands remain highly vulnerable to observed and future risks from climate change, on account of both climate and non-climate stressors (Nurse et al, 2014). The Federation of St. Kitts and Nevis is one such at-risk island state, whose vulnerability will be further exacerbated as the climate continues to warm. Of particular concern are the projected rates and consequences of sea level rise in a country whose principal settlements, economic and social infrastructure and the majority of its livelihood support systems are located within or near low-lying coastal areas. As for other small nations of the Caribbean and other island regions of the world, flooding, storm surge, erosion and other coastal hazards will likely be amplified and pose a direct threat to the majority of the Federation's livelihood support systems, under currently projected changes of climate.

3.2 General Climate of St. Kitts and Nevis

The Federation of St Kitts and Nevis constitutes two islands centered at latitude 17.20^{o}N, longitude 62.45^{o}W and latitude 17.18^{o}N, longitude 62.35^{o}W respectively. The general climate is tropical maritime, with a mean monthly temperature during the Northern Hemisphere summer months (June-September) around 28^{0}-29^{0} C, which becomes cooler during the winter months (December to April) to between 25-26^{o}C (see Fig. 1). The wet season typically lasts from May to December, during which period the islands typically receive around 100-200 mm of rainfall per month. The rainfall peaks during the months of May and October-November with about 180 mm, but a

secondary rainfall peak tends to occur during the month of July, at which time an average of about 150 mm of rainfall are recorded (see Fig. 2).

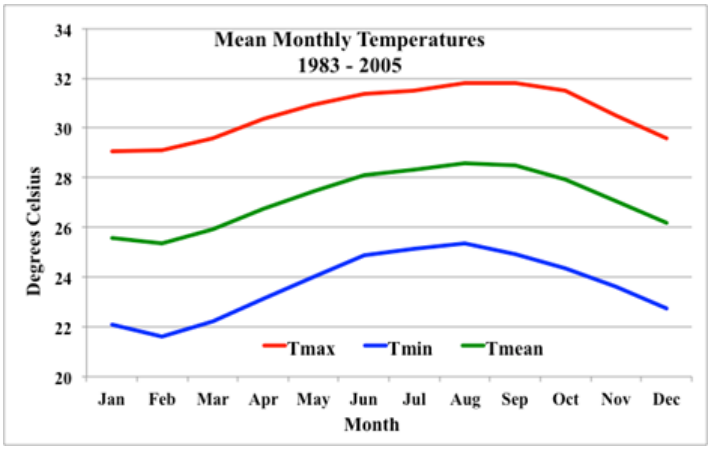


Figure 1 St. Kitts and Nevis Mean Monthly Temperatures, 1983-2005

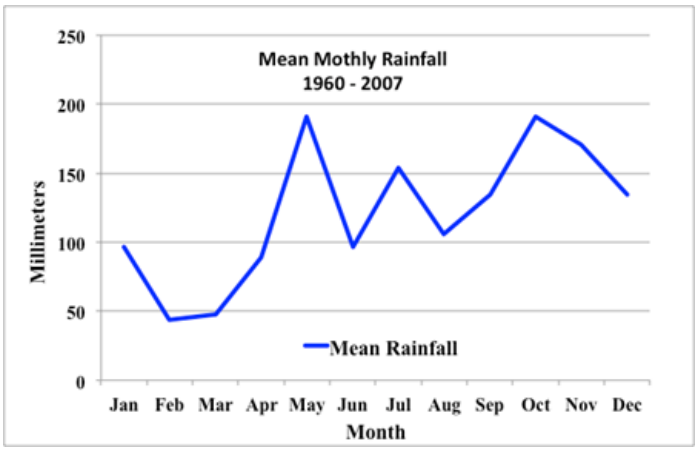


Figure 2 St. Kitts and Nevis Mean Monthly Rainfall, 1960-2007

The annual variability of the local climate is driven by the combination of eastward moving extra-tropical systems (such as the tail end of cold fronts during the winter and early spring, and the westward moving tropical systems (e.g. tropical waves, storms etc.) during the summer months. To a lesser degree, the behaviour of the North Atlantic Oscillation (NAO) also positively modulates both the timing and quantity of rainfall received. The inter-annual variability of the climate is further strongly influenced by the El Nino Southern Oscillation (ENSO) phenomenon. Warmer and drier than average conditions are experienced during El Niño episodes, while colder and wetter conditions typically occur during La Niña phases. St Kitts and Nevis are located on the southern edge of the Atlantic hurricane belt where cyclones and hurricanes occur during the June – November hurricane season. Most of the heavy rainfall events and larger rainfall quantities result from the passage of these tropical disturbances. Hurricane frequency and intensity are negatively correlated with incidences of El Niño and are positively correlated with La Nina events.

Consequently, there is more frequent hurricane activity associated with La Nina episodes, and fewer events in El Nino years.

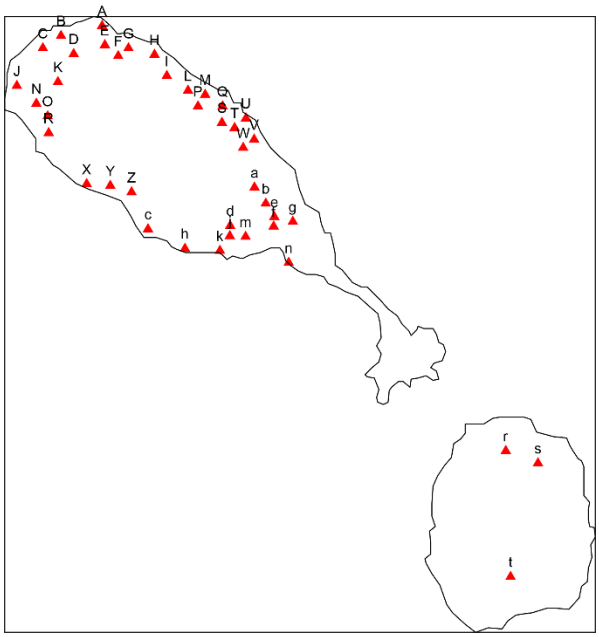
Some of the progressive changes in atmospheric elements, particularly in temperature and precipitation which are symptomatic of climate variability and change, are already being observed in the Federation of St Kitts and Nevis. The principal changes are briefly summarized below, based on the available observational records. The rainfall stations for which observational data exist are shown in Fig. 3.

3.2.*1 Temperature*

- While the average annual minimum temperature has not changed significantly from the 1980s through to the 2000s, the annual mean temperature and the annual mean maximum temperature have been increasing steadily at an average rate of 0.11^0C per decade and 0.2^0C per decade, respectively.
- There is insufficient daily observational data to identify trends in daily temperature extremes.

3.2.2 Precipitation

- The annual mean rainfall over St Kitts has been decreasing since the 1960s at an average rate of about 47 mm per decade.
- There is insufficient data to permit identification of any clear trend in extreme precipitation events.



Legend:

A *Caines Estate*
B *Willets Estate*
C *Belmont Estate*
D *Mount Pleasant Estate*
E *Parsons Estate*
F *Pogsons Estate*
G *Lynches Estate*
H *Belle Vue*
I *Stone Castle Tabernacle*
J *Cranstaun Estate*
K *Fahie Estate*
L *Estridge Estate*
M *Lower Mansion*
N *Sir Gilles Estate*
O *Farm's Estate*
P *Mansion Estate*
Q *Lower Bourryeau*
R *Bourkes Estate*
S *Lodge Estate*
T *Brighton Estate*
U *Hermitage Estate*
V *Cunningham Estate*
W *Spooners Estate*
X *Godwin Estate*
Y *Lambert's Estate*
Z *Wingfield Estate*
a *Stapleton Estate*
b *Douglas Estate*
c *Stone Fort Estate*
d *Olivees Estate*
e *RLB Airport*
f *Factory Yard*
g *Agronomy*
h *Garveys Estate*
j *Dewars Estate*
k *Camps Estate*
m *La Guerite*
n *Factory Pier*
r *Mount Pleasant*
s *Fountain*
t *Ponds*

Figure 3: Location of Rainfall Stations

3.3 Climate Change Models and Scenarios Used

A climate model is a quantitative way of representing the interactions of the atmosphere, oceans, land surface, and ice. General Circulation Models (GCMs) are a class of computer-driven models for weather forecasting, understanding climate and projecting climate change, using prescribed greenhouse gas scenarios. GCMs are highly complex and they represent the effects of such factors as reflective and absorptive properties of atmospheric water vapour, greenhouse gas concentrations, clouds, annual and daily solar heating, ocean temperatures and ice boundaries. The GCMs provide simulations of the global circulation patterns and seasonal cycles of the world climate. GCMs operate at a spatial resolution which often not at the level of small island developing states with grid boxes often around 2.5 degrees latitude and longitude. GCMs thus have difficulties providing information at the level of small island developing states. Thus for island states such as St. Kitts and Nevis, GCMs present significant problems as they are too small to feature.

Regional climate change models (RCMs) are now available for many regions globally. RCMs are often embedded or nested within GCMs, and provide information at a finer scale. RCMs thus allow for the presentation of information at the sub-GCM grid, through the process of downscaling.

The IPCC has defined a climate scenario as a plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as about the observed current climate.

The SRES scenarios were developed by the IPCC, to make future projections about climate change. The scenarios consist of four families or storylines. These are A1, A2, B1, and B2. The A1 storyline consists of a family of scenarios which puts forward a more integrated world.

The A1 scenarios are characterized by:

i. Rapid economic growth,
ii. A global population that reaches 9 billion in 2050 and then gradually declines,
iii. The quick spread of new and efficient technologies and convergent world - income and way of life converge between regions.
iv. Extensive social and cultural interactions worldwide.

There are a number of subsets and varying scenarios based on technological, these include A1FI which has an emphasis on fossil-fuels, A1B which has a balanced emphasis on all energy sources, while A1T has an emphasis on non-fossil energy sources.

The A2 scenarios are characterized by:

i. A world of independently operating, self-reliant nations.

ii. Continuously increasing population.
iii. Regionally oriented economic development.
iv. Slower and more fragmented technological changes and improvements to per capita income.

With the B1 Storyline the scenarios are of a world more integrated, and more ecologically friendly. The B1 scenarios are characterized by:

i. Rapid economic growth as in A1, but with rapid changes towards a service and information economy.
ii. Population rising to 9 billion in 2050 and then declining as in A1.
iii. Reductions in material intensity and the introduction of clean and resource efficient technologies.
iv. An emphasis on global solutions to economic, social and environmental stability.

In the B2 storyline the scenarios are of a world more divided, but more ecologically friendly. The B2 scenarios are characterized by:

i. Continuously increasing population, but at a slower rate than in A2.
ii. Emphasis on local rather than global solutions to economic, social and environmental stability.
iii. Intermediate levels of economic development.
iv. Less rapid and more fragmented technological change than in A1 and B1.

The Representative Concentration Pathways (RCPs) are four greenhouse gas concentration trajectories adopted by the IPCC for its fifth Assessment Report (AR5). The pathways are used for climate modelling and research. They describe four possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. The four RCPs, RCP2.6, RCP4.5, RCP6, and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W/m2, respectively). PRECIS is a regional climate modelling system, based on the third generation of the Hadley Centre's regional climate model (HadRM3). This direct are climate model is a semi-empirical downscaling model based on the principal argument that for small domains, the main modulators to the climatic elements' distribution within the domain, such as topography, proximity of bodies of water, etc., will continue to play the pivotal role in the local relative distribution of those elements, irrespective of the changes in the global climate drivers. This approach establishes an empirical model between all the available historical data stations within the domain, and then draws a comparative distribution of the local climate variables from the large-scale GCM variables. As a result, the downscaled distribution over the domain is determined directly from the statistical and spatial relationships derived from the historical data within the domain.

For this vulnerability analysis, the Direct Area Climate model [Charlery & Nurse, 2010] was used to perform the downscaling of rainfall and temperature over St Kitts for the projected period up to 2100 with the HadCM3 global climate model (GCM) was used as the primary SRES climate model

for simulating the atmospheric climate change process over St Kitts and the Caribbean. Three (3) scenarios were used for the simulations: A1B, A2 and B1.This model has a spatial resolution of 2.5° x 3.75° (latitude by longitude) which produces a surface spatial resolution of about 417 km x 278 km in the vicinity of St Kitts. The data from this model was then used as input into the high-resolution downscaling model to resolve the climate changes over St Kitts and Nevis. The HadGem2-ES model was used to provide the sea level rise data around St Kitts for the emissions scenarios of RCP2.6, RCP4.5, and RCP8.5

3.4 Model Outputs and Results.

3.4.1 Temperature

Annual Mean Temperature:

Annual mean temperatures across the Federation are anticipated to continue increasing under all scenarios modelled. Under the A1B scenario, the temperature is projected to increase by 0.72^0 C by 2020, 1.63^0 C by 2060 and 2.44^0 C by 2100, relative to the 1983-1999 mean. Similarly, under the A2 scenario, the mean annual temperature is projected to increase by 0.66^0 C by 2020, 1.53^0 C by 2060 and 2.99^0 C by 2100. In the case of the B1 scenario, the mean annual temperature can be expected to increase by 0.71^0 C by 2020, 1.43^0 C by 2060 and 2.12^0 C by 2100 (Fig. 4)**.**

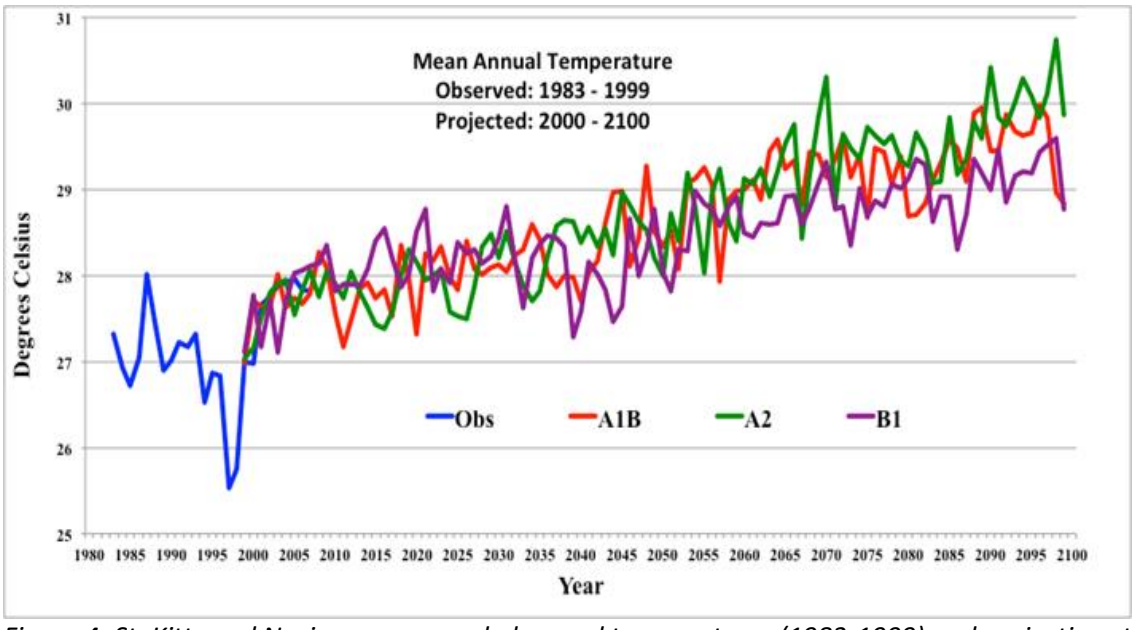


Figure 4: St. Kitts and Nevis mean annual observed temperatures (1983-1999) and projections to 2100 under SRES A1B, A2 and B1 scenarios.

Projected Annual Mean Minimum Temperature

The modelling experiments show a similar increasing trend for *minimum temperatures* up to the end of the present Century. Under the A1B scenario, the mean annual minimum temperature is

projected to increase 0.03^0 C by 2020, 0.84^0 C by 2060 and 1.85^0 C by 2100. For the A2 scenario, the projected increases are 0.21^0 C by 2020, 0.96ºC by 2060 and 2.48ºC by 2100. In the case of the B1 scenario, the mean annual minimum temperature is projected to increase by 0.03^0C by 2020, 0.47^0C by 2060 and 1.01^0C by 2100 (Fig. 5).

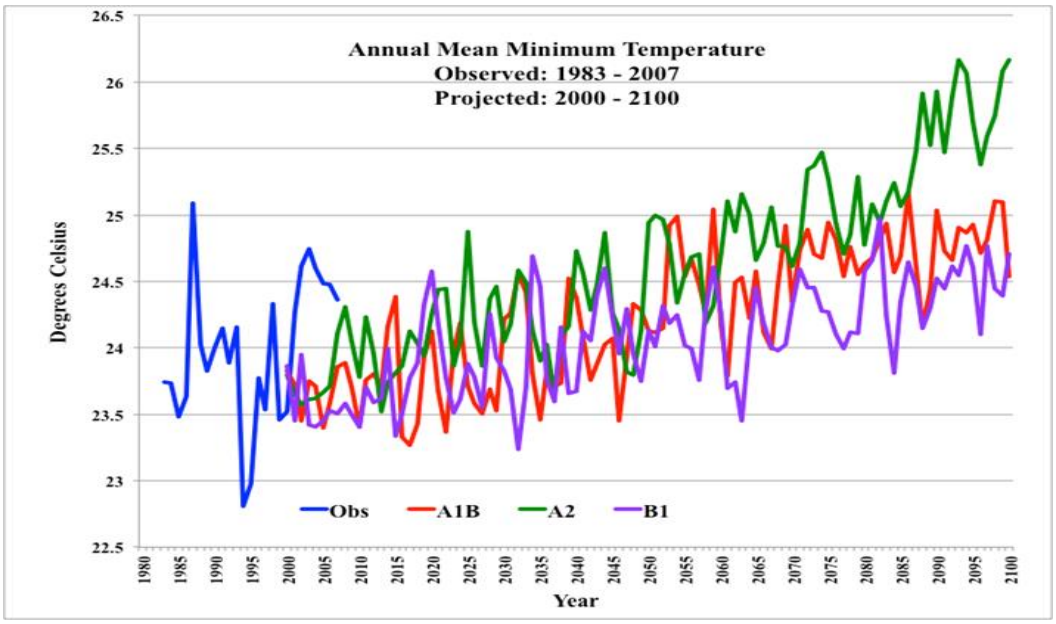


Figure 5: St. Kitts and Nevis mean annual minimum observed temperatures (1983-2007) and projections to 2100 under SRES A1B, A2 and B1 scenarios.

Projected Annual Mean Maximum Temperature

As in the case of mean annual and mean minimum temperatures, increases in *annual mean maximum* temperatures can also be anticipated across St. Kitts and Nevis. Model runs based on the A1B scenario project increases of 0.05^0 C by 2020, 1.03^0 C by 2060 and 1.48^0 C by 2100. Under the A2 scenario, the mean annual maximum temperature is projected to increase by 0.27^0 C by 2020, 1.21^0 C by 2060 and 2.61^0 C by 2100. Projections for the B1 scenario show annual mean maximum increases of 0.01^0 C by 2020, 0.57^0 C by 2060 and 1.01^0 C by 2100 (Fig. 6).

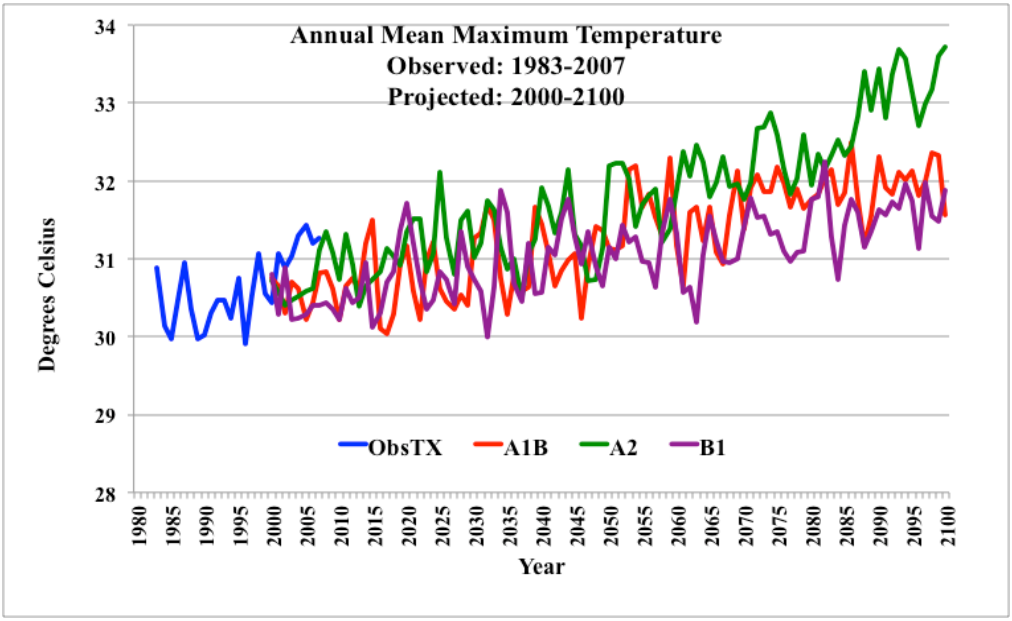


Figure 6: St. Kitts and Nevis mean annual maximum observed temperatures (1983-2007) and projections to 2100 under SRES A1B, A2 and B1 scenarios.

3.5 Rainfall

In all the months, most of the precipitation received in St Kitts is invariably concentrated in the central and north-western section of the island, while the lowest amounts are received in the southern section – including the Southeast Peninsula. In Nevis on the other hand, most of the precipitation is concentrated in the north-eastern quadrant of the island while the lowest amounts are observed in the southwestern region of the island. The high definition downscaling process from the Direct Area Downscaling model has captured those features accurately in the historical period (1960-2005) and maintains the relative distributions across the A1B, A2 and B1 scenarios of the HadCM3 GCMs through the 21st Century. Comparative projections for the time period 2050-2059 (medium term) for each of the three scenarios are provided in Figs. 7-10. Additional outputs representing rainfall projections for the three scenarios in the decades of the 2020s and 2090s are provided in Appendix 1.

Although there is a general and progressive reduction in the projected annual rainfall over St Kitts and Nevis, ranging between 3% and 48% during the 21st Century, the change in the future precipitation is not being indicated as either monotonic or consistent across the different months of the year or across decades. In fact, the decadal means for some months are characterized by increased precipitation over the observed normal (e.g. November and December in the decade of the 2050s) while significant reductions are indicated in the wet season (May-November) for all the scenarios. Table 1 provides the details for each of the months, under the different scenarios, during the decades of the 2020s (*near-term*), 2050s (*medium-term*) and 2090s (*long-term*).

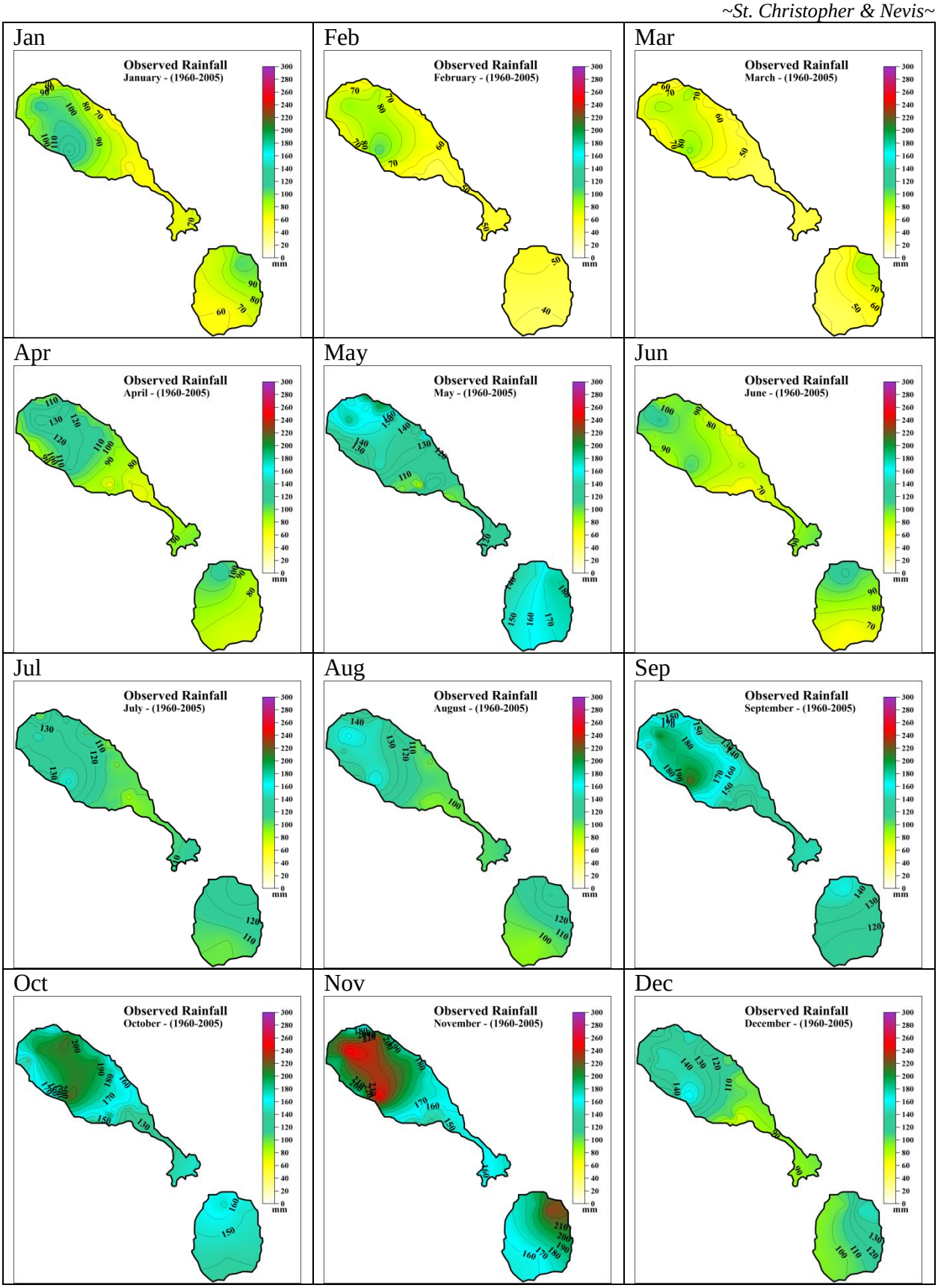


Figure 7 Mean monthly rainfall for St Kitts and Nevis for the period 1960 – 2005

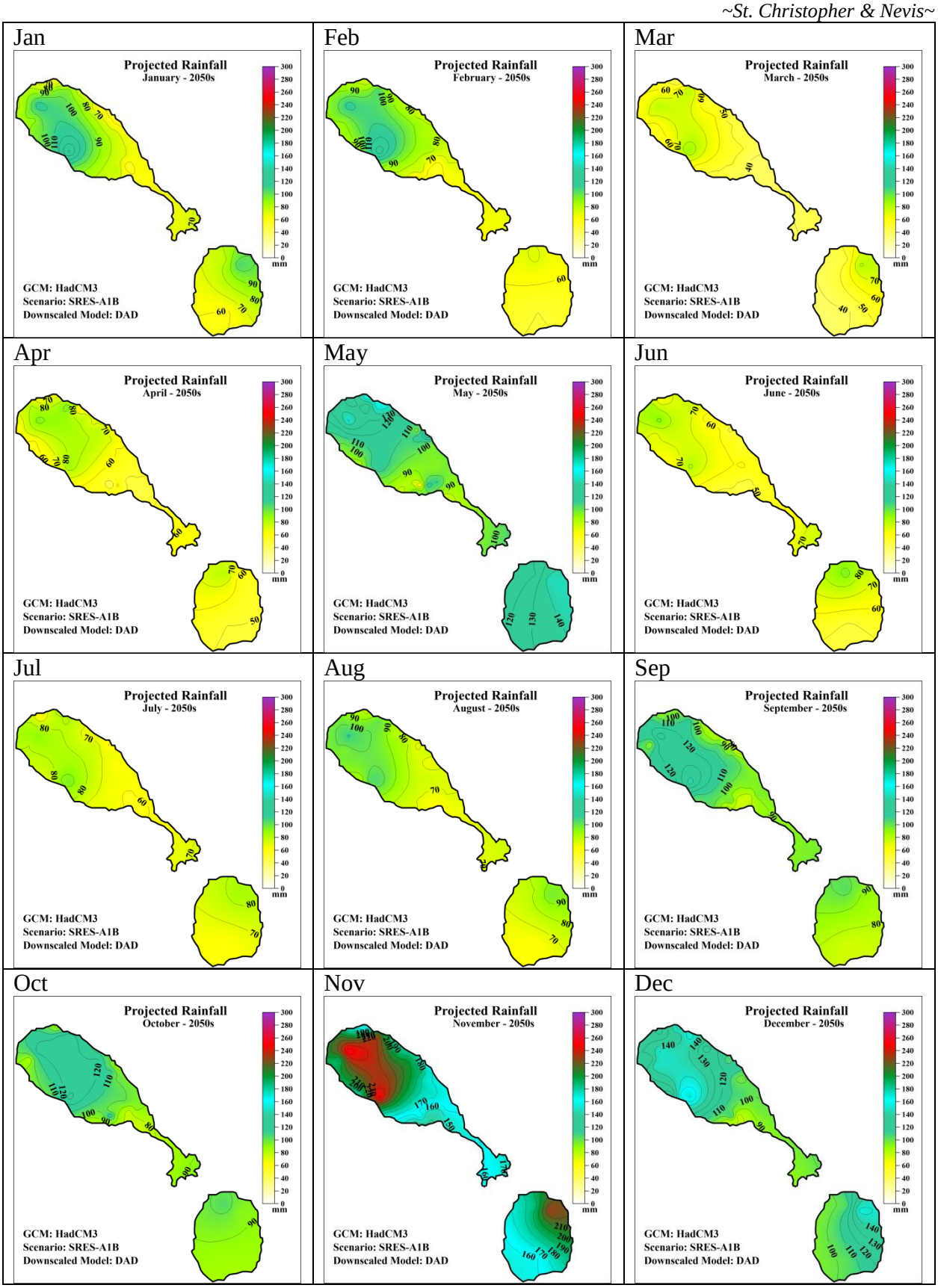


Figure 8 Projected mean monthly rainfall, St Kitts & Nevis, 2050-2059 under the A1B scenario

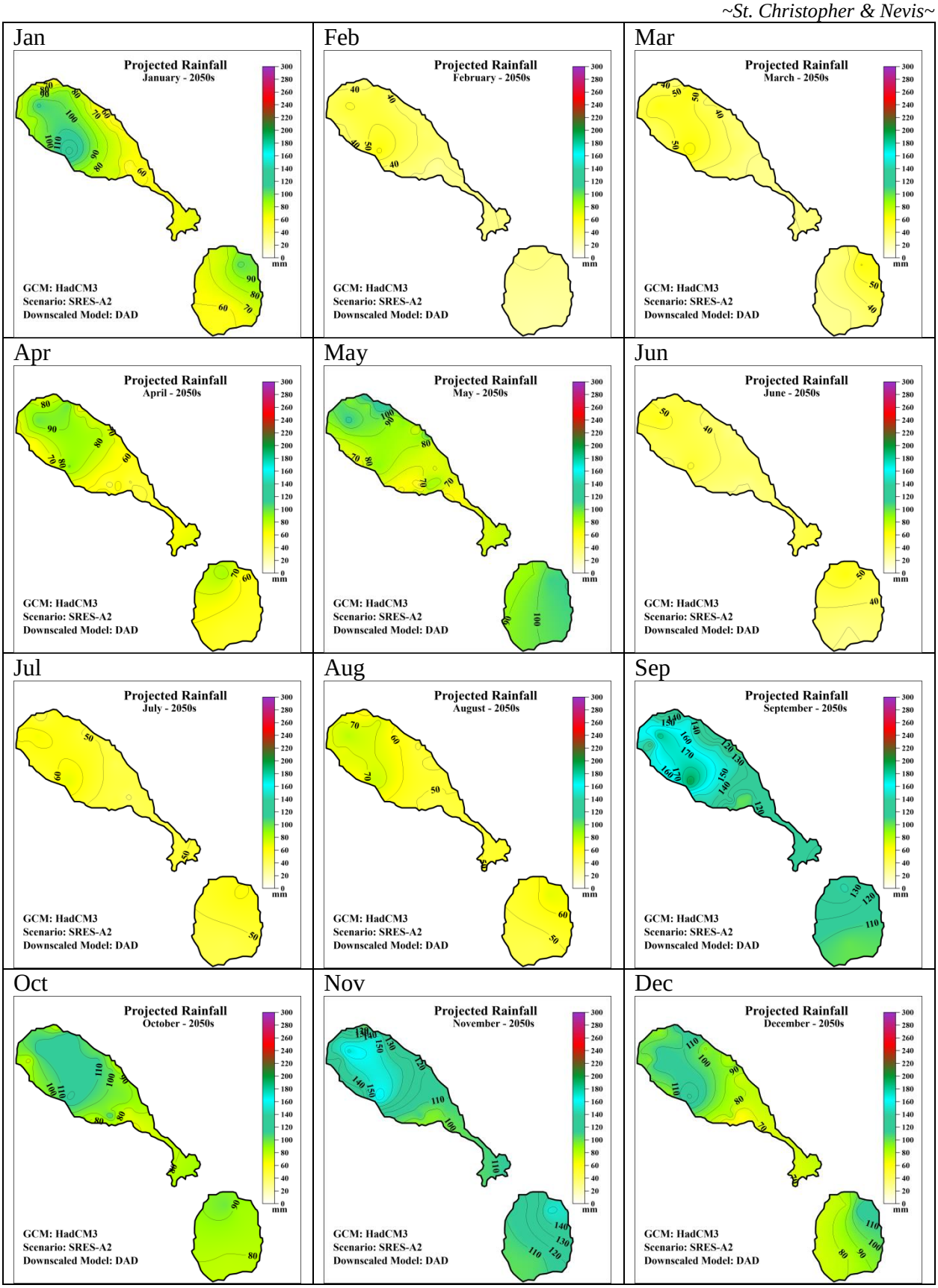


Figure 9 Projected mean monthly rainfall, St Kitts & Nevis, 2050-2059 under the A2 scenario

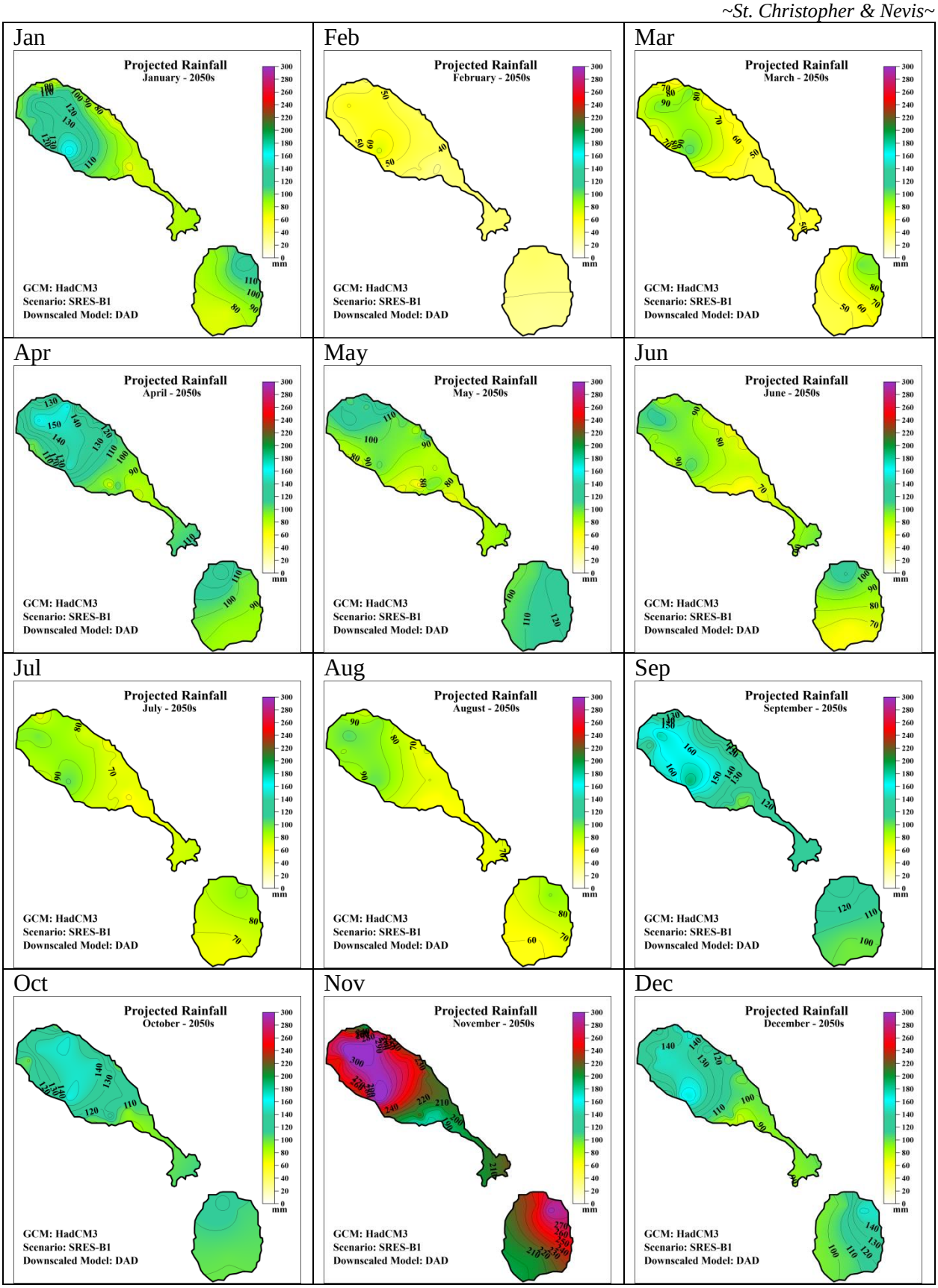


Figure 10 Projected mean monthly rainfall, St Kitts & Nevis, 2050-2059 under the B1 scenario

	2020s	2050s	2090s
Jan	A1B = -3.6 A2 = -3.9 B1 = 30.8	A1B = -0.2 A2 = -3.7 B1 = 19.7	A1B = -10.8 A2 = -36.0 B1 = -24.1
Feb	A1B = -10.3 A2 = -39.4 B1 = 6.4	A1B = 29.0 A2 = -41.6 B1 = -31.8	A1B = 16.1 A2 = -35.4 B1 = -3.7
Mar	A1B = -6.4 A2 = -11.1 B1 = 4.6	A1B = -7.0 A2 = -30.9 B1 = 13.2	A1B = -18.9 A2 = -1.4 B1 = -7.8
Apr	A1B = -0.5 A2 = -0.1 B1 = 68.2	A1B = -32.4 A2 = -28.3 B1 = 17.1	A1B = 26.0 A2 = 25.2 B1 = -24.8
May	A1B = 14.3 A2 = 4.8 B1 = -7.6	A1B = -19.4 A2 = -39.0 B1 = -30.4	A1B = -19.7 A2 = -62.3 B1 = 4.9
Jun	A1B = 1.4 A2 = -10.3 B1 = 27.2	A1B = -24.8 A2 = -52.4 B1 = -1.9	A1B = -57.2 A2 = -57.9 B1 = -45.3
Jul	A1B = -17.1 A2 = -20.7 B1 = -18.2	A1B = -38.3 A2 = -55.5 B1 = -33.4	A1B = -70.1 A2 = -69.7 B1 = -40.9
Aug	A1B = -10.7 A2 = -32.2 B1 = -13.9	A1B = -32.2 A2 = -51.6 B1 = -35.8	A1B = -66.9 A2 = -73.2 B1 = -34.9
Sep	A1B = 26.8 A2 = -13.3 B1 = -16.4	A1B = -33.9 A2 = -9.5 B1 = -12.7	A1B = -65.8 A2 = -63.5 B1 = -25.4
Oct	A1B = -11.6 A2 = -32.5 B1 = -19.5	A1B = -39.1 A2 = -43.4 B1 = -28.1	A1B = -66.6 A2 = -74.0 B1 = -33.3
Nov	A1B = -15.3 A2 = -4.8 B1 = -37.4	A1B = 0.2 A2 = -33.5 B1 = 28.0	A1B = -31.7 A2 = -31.5 B1 = -11.2
Dec	A1B = -13.4 A2 = 4.6 B1 = -9.2	A1B = 3.2 A2 = -20.3 B1 = 2.7	A1B = -28.6 A2 = -35.5 B1 = -7.2
Annual	A1B = -3.5 A2 = -12.9 B1 = -4.7	A1B = -18.9 A2 = -34.3 B1 = -8.5	A1B = -38.0 A2 = -47.2 B1 = -21.3

Table 1: Projected mean monthly rainfall changes (%) from the observed 'normal' under SRES A1B, A2 and B1 scenarios for the decades of the 2020s, 2050s and 2090s.

For the seasonal changes, an increase of between 7 – 18% in rainfall is projected under the B1 scenario during the dry season (December – April) over the present amount, after which a steady reduction in precipitation is expected during the second half of the Century. This projection is not

supported by the A1B and A2 scenarios. Rather, a percentage reduction of about 9-19% during the dry season of the 2020s to 0-45% during the mid-Century to 25-47% by the 2090s. For projected wet season rainfall (May – November) the sign of the change is consistent throughout the Century for the A1B, A2 and B1 scenarios. This projected reduction in rainfall can be anticipated to vary from about 2-15% in the 2020s to 16-40% in the 2050s, increasing to between 25-60% by the end of the Century (see Table 2).

Decade	Scenario	Dry Season (DJFMA)	Wet Season (MJJASON)
2020s	A1B	-18.6	-1.8
	A2	-9.0	-15.6
	B1	18.3	-12.3
2050s	A1B	0.5	-26.8
	A2	-46.4	-40.7
	B1	7.2	-16.3
2090s	A1B	-25.5	-54.0
	A2	-47.4	-61.7
	B1	-22.3	-26.6

Table 2: Projected percentage change from observed 'normal' in seasonal rainfall, by season, under SRES A1B, A2 and B1 scenarios.

3.6 Sea Level Rise

Tidal data was collected in the nearby location of St Croix (Lime Tree Bay) in the Virgin Islands during the period 1977-2006, reported a steady increase of sea level rise of 1.74 mm per year during that time (*Source: http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml*). Projections for sea level rise in the vicinity of St Kitts and Nevis are taken from the Hadley Centre's HadGem2-ES model, using the Representative Concentration Pathways (RCPs), and are considered for low (RCP2.6), medium (RCP4.5) and high (RCP8.5) emission scenarios. The results for the low and medium emission scenarios project a steady increase in sea level rise of 0.3 m and 0.53 m respectively over the present sea level by the end of the 21st Century. The results for the high emission scenario (RCP8.5) project an increase of 1.2 m over present mean sea level by the end of the same period. These projections are shown in Fig. 11 and Table 3.

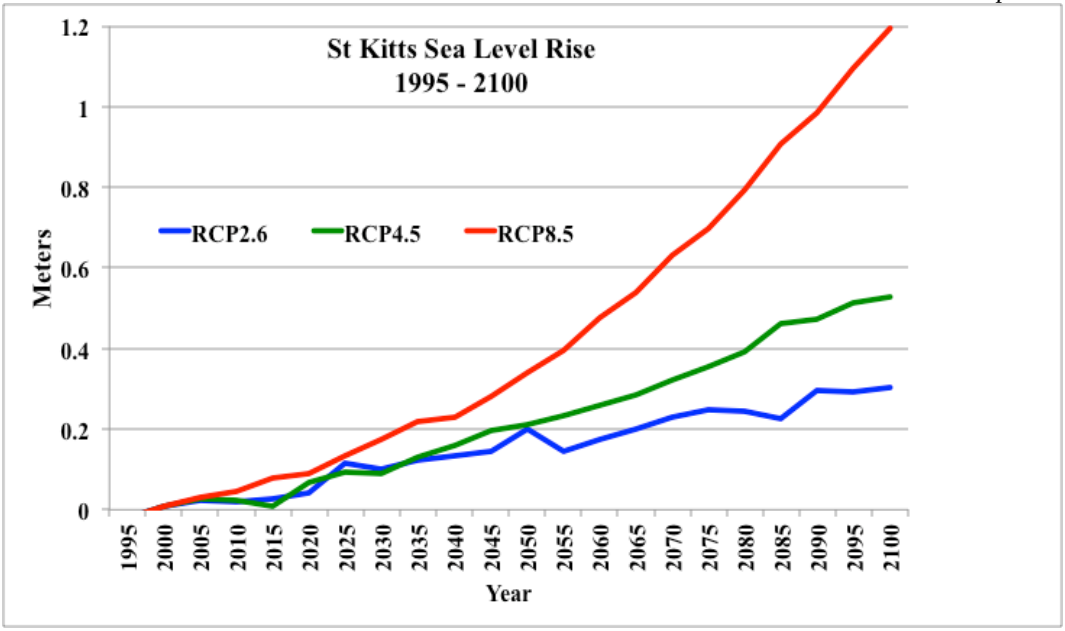


Figure 11: Sea level rise projections for Kitts and Nevis, 1995-20, under RCP 2.6, 4.5 and 8.5

Year	RCP2.6	RCP4.5	RCP8.5
1995	-0.0202	-0.0208	-0.022
2000	0.0078	0.0085	0.01
2005	0.024	0.026	0.031
2010	0.0204	0.0236	0.044
2015	0.0262	0.0085	0.08
2020	0.04	0.0672	0.09
2025	0.1139	0.0931	0.135
2030	0.1003	0.091	0.174
2035	0.1215	0.1289	0.217
2040	0.1328	0.1611	0.229
2045	0.143	0.1947	0.28
2050	0.2016	0.2101	0.339
2055	0.1454	0.235	0.395
2060	0.1725	0.26	0.478
2065	0.2005	0.2839	0.539
2070	0.2303	0.3214	0.632
2075	0.2474	0.3563	0.699
2080	0.2452	0.3928	0.792
2085	0.2261	0.4602	0.906
2090	0.2953	0.4726	0.986
2095	0.294	0.5131	1.094
2100	0.3034	0.5274	1.196

Table 3: Sea level change for St. Kitts and Nevis, 1995-2100, unit is in cm.

3.7 Sea Surface Temperatures (SST)

Observed SST taken from the AVHRR (1985-2010) and simulated SST downscaled by the PRECIS regional climate model with boundary data from the ECHAM4 GCM, indicate a progressively increasing warming trend for the SST waters of the north-eastern Caribbean, which includes the territories of St Kitts and Nevis. This warming trend is characterized by a steady increase of the mean SST of about 0.02ºC per annum during the period 2000 – 2030, which is then replaced by a sharp increase of about 0.05ºC per annum from the decade of the 2030s through to the end of the 21st century. This trend is consistent in the simulations for both the SRES A2 and B1 scenarios.

3.8 Tropical Storms, Hurricanes and Storm Surge

3.8.1 Tropical storms and hurricanes

Owing to its location, the Federation of St Kitts and Nevis is extremely exposed to the effects of tropical storms and hurricanes. Several analyses based on the observed, historical record have reported an increase in the number of these systems in the last 30 years (e.g. Webster et al., 2005; Holland and Webster, 2007; Kossin et al., 2007; Elsner et al., 2008). While there is still some uncertainty about the direction of change in the frequency of these events in a changing climate, recent studies suggest that the frequency of storms may decrease due to reduced vertical wind shear as a result of increased warming (Vecchi and Sodon, 2007; Bengtssen et al., 2007; Emanuel et al., 2008, Knutson et al., 2008). Yet some studies project an *increase in hurricane intensity*, despite projected decreases in frequency (Emanuel et al., 2008; Knutson et al., 2008).

The Federation has suffered considerable damage from storm and hurricane events in the recent past, and it should be noted that these systems do not need to pass directly over the islands to inflict heavy economic and social losses. Since 1950, 16 such events have passed within 100 km of the islands (Global Facility for Disaster Reduction and Recovery [GFDRR], 2010), causing loss of life and extensive economic and social disruption. In its Initial National Communication to the UNFCCC, it was reported for example that in 1989 Hurricane Hugo caused an estimated USD43 million in damage, and in 1998 losses resulting from the passage of Hurricane Georges amounted to some USD 445 million. This included damage to 80% of the country's housing stock and a substantial portion of the tourism plant, utilities and other economic and social infrastructure (GFDRR, 2010). In 1995, two hurricanes Luis and Marilyn, made landfall resulting in combined losses amounting to USD 55 million. In 2008 Hurricane Omar, a category 4 system, passed 150 km east of the Federation, yet caused considerable damage to the Four Seasons Resort, the single largest employer and revenue earner on the island and major socio-economic dislocation (Ibid). It is estimated that the resort employed between 700-800 persons directly and indirectly in related activities, e.g. scuba diving, craft making, tour guides etc. (Marcello, 2011). The resort was closed for two more than 2 years after the passage of Omar, before reopening in 2011 after renovations totalling EC $120 million (Marcello, 2011).

In St Kitts and Nevis the greatest risk for flooding and landslides comes from periods of heavy rain associated with events such as hurricanes and tropical storms. Although much of the upper watersheds in St. Kitts and Nevis are still forested, deforestation in the flat areas near the coast makes settlements vulnerable to flooding (Cooper, 2001). Mass movement of soils and rocks can also create problems during floods. Bank collapse from erosion at locations such as College Street Ghaut (near Monkey Town) and in Canyon Ghaut, have presented great challenges to properties near the river bank (Cooper, 2001). Fig. 12 shows some of the highly vulnerable (dark blue and brown) areas within Basseterre, and neighbouring areas that are regularly affected by flooding (pink and yellow). Vulnerable areas in the rest of the island were mostly in the northern coastal areas and are generally of lower risk levels.

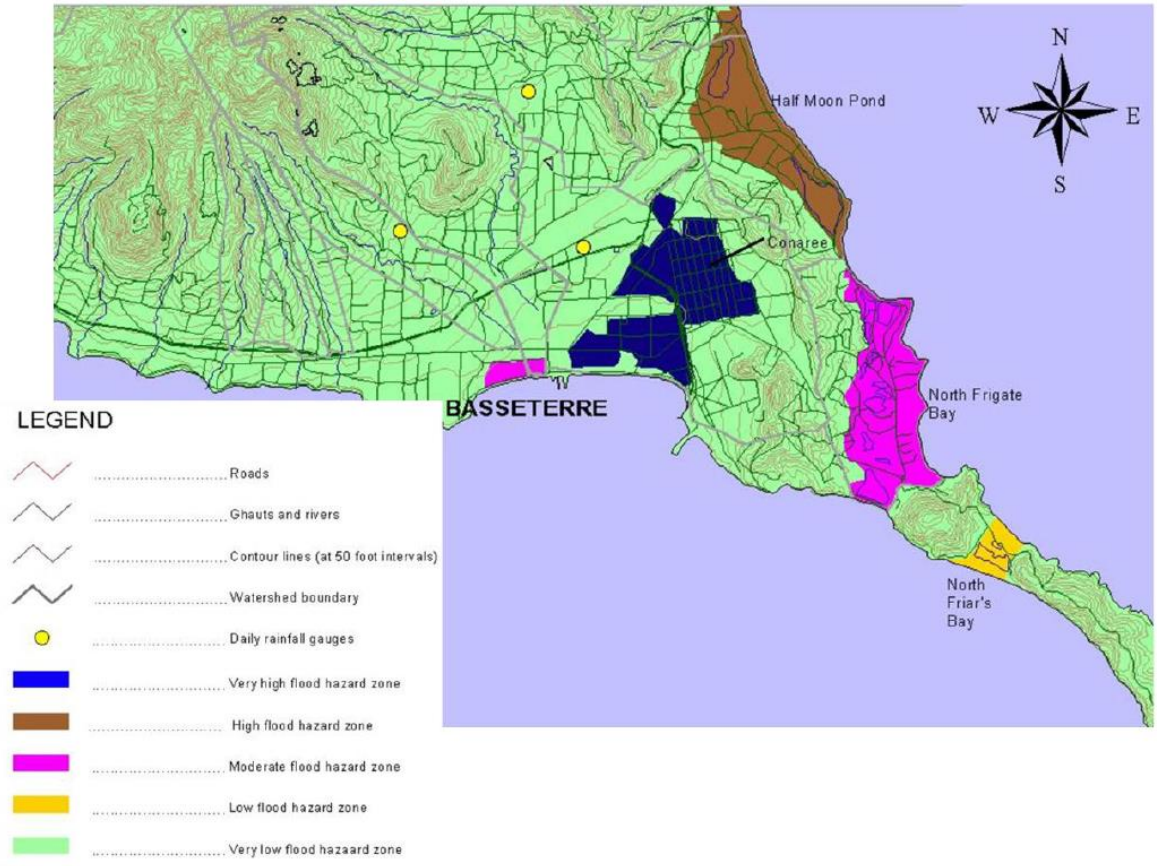


Figure 12: High risk areas for flooding, Basseterre and environs (Source: USAID)

3.8.2 Storm Surge

Storm surge heights and risks vary considerably with return period of a given storm event. In a hazard assessment study for St. Kitts and Nevis, OAS-USAID (2001) reported generally low vulnerability to storm surge for the 1:10 year event, although areas bordering Dieppe Bay and Dowson's Ghaut, Grange Bay, North Friars Bay, the southwestern region of the Southeast Peninsula, South Friars Bay and the Basseterre waterfront would be at greater risk than elsewhere.

Surge heights associated with the 10 year return period ranged from 0.1- 0.5 m. The results further demonstrated that with the exception of the northeast coastal segment (Mosquito Bay - Hermitage), most of the St. Kitts coast would be at moderate risk from the 25-year return storm which could generate surge heights between 0.5- 1.5 m. For the 1:50 year event, the Caribbean coast along with the segment from South Friars Bay to Frigate Bay would be considered moderately vulnerable, and surge would also reach the Factory Tank area (OAS-USAID, 2001). Not surprisingly, practically the island's entire coastline, except for Pump Bay, would be exposed to moderate surge heights from a 1:100 year storm event.

As for St. Kitts, the OAS-USAID (2001) report suggests that vulnerability to the 1:10 year return event was negligible or low for Nevis. However, Fort Charles, the Deep Water Port and Charlestown Port would be exposed to surge heights of between 0.1-0.5 m. For the 1:25 year storm, surge heights between 0.5 and 1.5 m could be experienced along the Atlantic coast from Hurricane Hill to south of White Hall Estate (OAS-USAID, 2001). The region extending from Mosquito Bay to Dogwood Estate would be exposed to moderate surge from the 1:50 year event. Nearly all coastal segments of Nevis would be vulnerable to surge from the 1:100 year storm.

The potential serious impact of the above storm surge computations should not be underestimated, as the relationship between storm surge and wave height is not a linear function. Novaport Vaughan International (1993) showed that the 1:50 year storm would generate a surge of 0.26m, but wave heights of 4.9m in the vicinity of the Port of Basseterre. Deane (1973) had earlier calculated that for most areas in the Caribbean a 1:50 year event coinciding with astronomical high tide could raise water levels by as much as 5.5m. Nurse (1993) in a study at Banana Bay found that surge varying between 0.25 and 0.40 m would raise water levels at the coast by 3.5-4.5m. Surge and water level heights in the same range of magnitude were also estimated for North Frigate Bay (Nurse, 1994).

3.9 Beach Erosion and Coastal Land Loss

Beach erosion has been known to be a recurring challenge in St. Kitts and Nevis throughout its recent history (Cambers, 1983). While periodic beach accretion has occurred at some locations in the past four decades, measurable erosion has been recorded at most sites, particularly following the passage of tropical storms and hurricanes, and long period northerly swell triggered by extra-tropical systems, mainly cold fronts (Nurse, 1992). Indeed most of the 21 beaches monitored by the Fisheries Division and the Physical Planning Division since 1993 have been classified as *medium* to *very high* erosion zones and 5 out of 6 beaches evaluated on the exposed windward coast have been categorized as being highly or very highly vulnerable to the beach erosion hazard (OAS, 2001).

Simpson et al (2010) projected that almost 40,000 m^2 of beach loss and a coastal land area of 183,000 m^2 at the Marriott Resort and Royal Beach Casino in Frigate Bay (see Fig. 13), while sea level rise of 0.5 m could result in a 50% loss and inundation along the Irish Bay, Basseterre Bay

and Sugar Bay coasts (Fig. 14). The study concluded that a 1.0 m rise in sea level along the St. Kitts coast would cause more than 50% inundation at nearly all sites. In the case of Nevis it was found that > 6782 m^2 of beach area would be lost under a 2.0 m flood scenario at Oualie Beach and total land loss of >20,112 m^2. Similarly, 40% of high quality beach at Jessups, Oualie and Pinney's Beach would be inundated, with a 0.5 m rise in sea level (See Figs. 15 and 16). Under a sea level rise scenario of 1.0 m, all study sites would be >50% inundated (Ibid). Overall, a significant percentage of the Nevis coastal area is vulnerable or highly vulnerable to the coastal erosion hazard (Fig. 17), and this vulnerability can be expected to increase with projected changes in climate and associated sea level rise.

Figure 13: Projected beach and coastal land loss associated with various sea level rise scenarios, Marriott St. Kitts Resort and Royal Beach Casino, Frigate Bay (Source: Simpson et al, 2012).

Figure 14: Projected coastal land loss under various sea level rise scenarios, Basseterre Bay (Source: Simpson et al, 2012).

Figure 15: Projected coastal land loss under various sea level rise scenarios, Oualie Beach, Nevis (Source: Simpson et al, 2012).

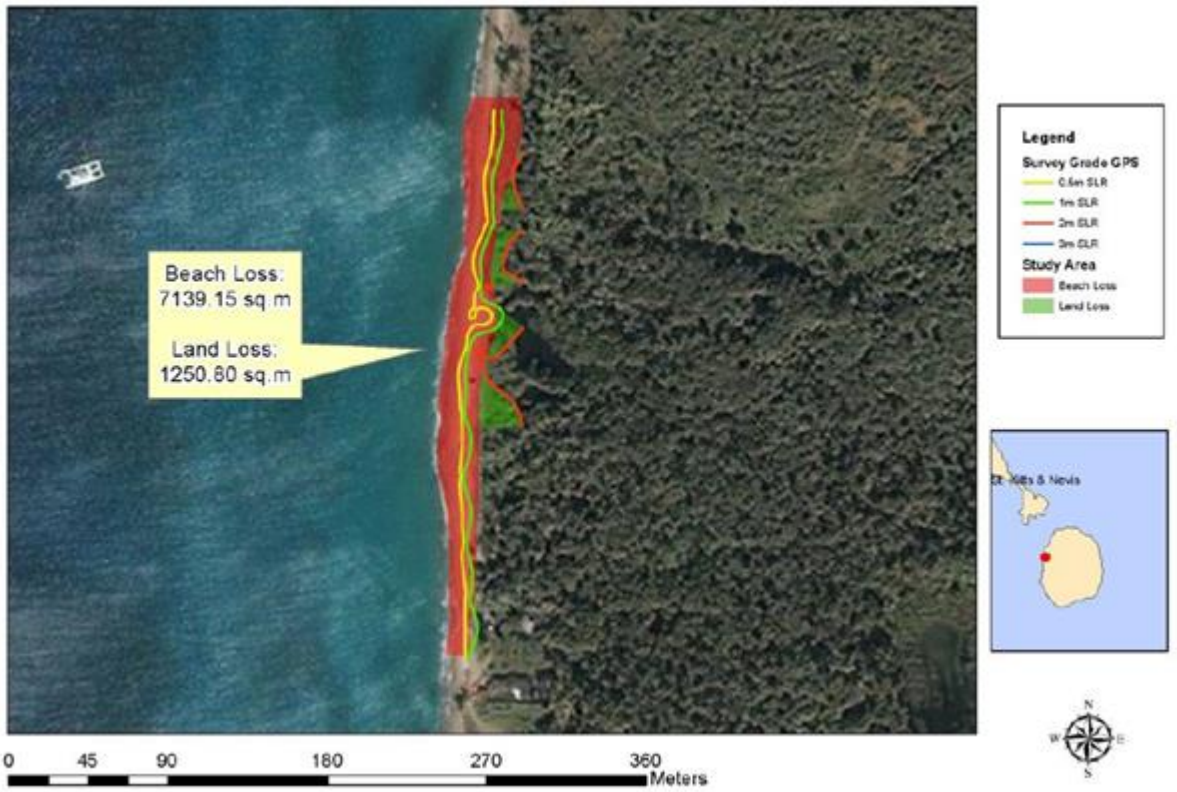


Figure 16: Projected coastal land loss under various sea level rise scenarios, Pinney's Beach, Jessups, Nevis (Source: Simpson et al, 2012)

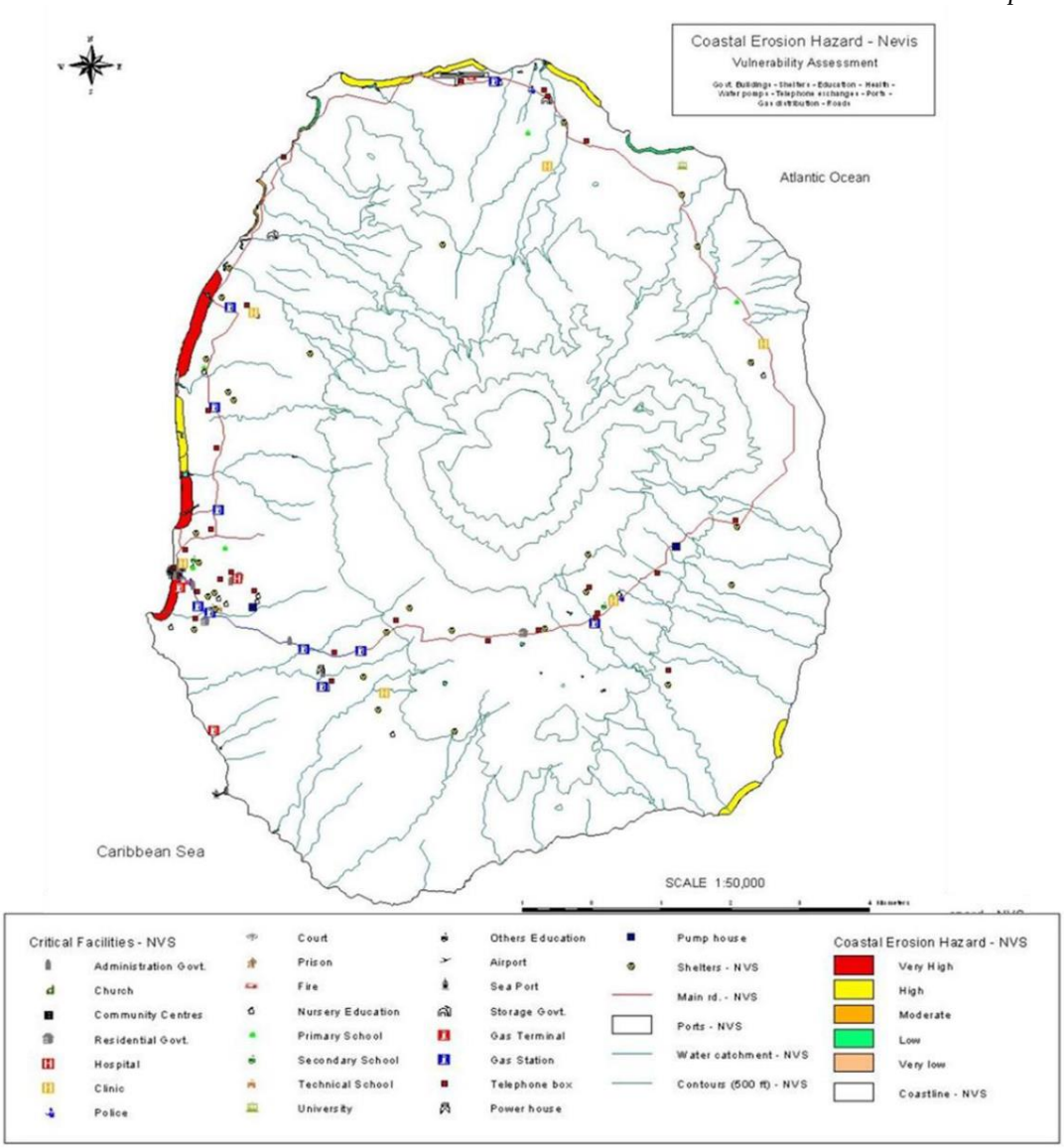


Figure 17: Nevis coastal erosion hazard map (Source: OAS-USAID, 2001)

3.10 Potential adaptation options to minimize risks from sea level rise, high-energy coastal events and storm surge

Adoption and application of the principles of integrated coastal area management (ICAM) can provide an effective, '*no regret*' adaptation response. Many of these options are also specifically designed to minimize risk to coastal settlements, infrastructure and other assets, while building resilience to climate-related risks. ICAM has three broad goals that are relevant to climate change adaptation planning in coastal and marine areas, namely

i. Avoiding development in areas vulnerable to storm waves and inundation;
ii. Ensuring that critical marine ecosystems retain their viability and ecological functionality; and

iii. To protect (or minimize damage to) human beings, critical infrastructure and economic activities in the coastal area from the action of the sea.

These objectives can be achieved by adopting a combination of the following management and adaptation options:

- Implementation of strict coastal development controls such as the use of appropriate construction setback limits and zoning to ensure that there is compatibility of activities. In highly exposed and vulnerable areas, restriction of development or even prohibition should be considered where appropriate. In some circumstances, consideration may also have to be given to government acquisition of vulnerable lands at fair market value.

- Prohibition of activities that compromise natural coastal protection – e.g. removal of mangroves and other coastal vegetation; mining of beach sand; filling of coastal wetlands.

- Elevation of structures (e.g. on piles, or 'stilts' in the case of Guyana and Belize) to cope with flooding/inundation from associated sea-level rise and storm surge.

- The use of coastal protection structures such as groynes, seawalls, breakwaters and revetments to stabilize beaches and protect valuable backshore property and critical infrastructure from such threats as wave erosion, storm surge, flooding and inundation.. However, care must be exercised to ensure that these do not trigger maladaptive effects elsewhere along the shoreline. In this regard, the application of building codes such as minimum ground floor elevations and imposition of minimum engineering design criteria for coastal protection structures should be mandatory.

- Improved coastal drainage – to facilitate more efficient retreat of flood waters, without causing unintended harm/damage to coastal ecosystems.

- Where possible, undeveloped coastal lands can be left in that state to provide an opportunity for mangroves and other vegetation to migrate landward in response to sea-level rise.

- Provision of incentives and access to funding for purchase of appropriate insurance products, e.g. to minimize dislocation after hurricane and flood events.

- Design and implementation of *Early Warning Systems*, preparedness and evacuation plans to assist communities to better cope with high-energy wave events such as hurricanes and storm surge.

3.11 Coastal Ecosystems

3.11.1 Corals

Coral reefs protect the shoreline of St. Kitts and Nevis and constitute a vital element of the Federation's biodiversity. The reefs make a significant contribution to tourist and recreational activities (e.g. through snorkelling, diving, viewing from glass bottom boats, etc.), and support artisanal, commercial and recreational fisheries. Coral reefs function as habitat, feeding and nursery grounds for juvenile fish, molluscs, crustaceans and marine reptiles. They are also a significant source of beach sand. This sand source is important for the continued existence of the beaches, which also contributes to natural shoreline protection. In St. Kitts, coral reefs are found along the southwest coast between Nag's Head and the southern end of Basseterre Bay, on the northwest coast between Sandy Point and Dieppe Bay, on the east coast between Conaree and Friar's Bay and on the southeast coast adjacent to the Narrows (MOSD, 2007). Agostini et al (2010) note that the diversity of corals in St Kitts and Nevis includes species classified by the International Union for Conservation of Nature (IUCN) as *critically endangered* (e.g. staghorn [*Acropora cervicornis*] and elkhorn [*Acropora palmate*]), as well as more common, ubiquitous species (e.g. finger coral [*Porites divaricata*]). The coral reefs of St. Kitts and Nevis are subject to a range of anthropogenic stressors that contribute to their deterioration. These include liquid and solid waste pollution from physical marine and land-based sources, damage from divers and boats, and overfishing which disrupts the reef community and promotes algal growth. In addition, sediment-laden runoff into coastal areas particularly after heavy rainfall events, appears to have increased significantly since the closure of the sugar cane industry.

Existing risks to corals will be exacerbated by a number of climate change related stressors including higher sea surface temperatures (SST) and increasing ocean acidification. Coral reefs are extremely vulnerable to thermal stress and those in the Caribbean generally exist at or near the limit of thermal tolerance. Elevated SST has long been shown to be a major factor in coral bleaching in the Caribbean (Oxenford et al, 2008; Rodriguez et al, 2010). At temperatures above 'normal' seasonal maxima they lose their symbiotic algae (zooxanthellae), pale in colour and undergo bleaching. Observed sea surface temperature (SST) from the HadSST2 gridded dataset indicates a statistically significant trend of increasing SST of about 0.09˚C per decade in the waters surrounding St. Kitts and Nevis for the period 1960-2006. While the largest increase has been observed during the months of June, July and August (+0.12˚C), the projections indicate that measurable SST increases occur throughout the year. Projected increases range from +0.7˚C and +2.8˚C by the 2080s across all emission scenarios. The range of projections under any single emissions scenario spans roughly 1.0 to 2.0˚C (Ibid). SST increases of about 1^0C- 3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatization by corals (Nicholls, 2007). Increased incidence of bleaching reduces the recovery time for the stressed corals, consequently leading to higher morbidity and mortality.

Higher SST facilitates the uptake of increased CO_2 by the ocean causing a reduction in seawater pH and a consequent increase in ocean acidification. Increased acidification is widely expected to cause a reduction in carbonate accretion rates, which would place reefs under further stress and reduce their resilience and diversity (Hoegh-Guldberg et al, 2007; IPCC, 2007b; Munday et al, 2012; IPCC 2013). As elsewhere, the waters surrounding the Federation of St. Kitts and Nevis will not be protected from this threat, thus the survival of the country's reefs is likely to become more uncertain under a consistently warming climate. Evidently, loss of corals will have a simultaneously negative impact on beach and coastal stability as well as the tourism and recreation sector.

3.11.2 Seagrasses

Seagrass beds are an important constituent of the marine ecosystem of St. Kitts and Nevis. There are several large seagrass beds around St. Kitts and Nevis particularly in the area known locally as '*The Narrows*', which separates the two islands. These benthic communities mainly comprise turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*). These provide vital ecological services including (i) functioning as primary producers in the food chain of the reef community (ii) nitrogen fixing (iii) functioning as habitat, feeding, breeding, recruitment sites and nursery grounds for juveniles and adults (iv) reducing the amount of sediment entering nearshore waters (v) trapping suspended sediment that settles through the water column and decreasing turbidity.

Potential climate change threats to seagrass ecosystems arise from various sources. These include sea level rise, changes in localized salinity, increased SST and intensity of extreme weather events such as storms. As with corals, SLR may reduce the sunlight available to seagrass beds and hence reduce their productivity. Intense hurricanes can uproot seagrass beds as was the case with Hurricanes Luis in 1995, which ripped the seagrasses from the substrate and deposited masses of the vegetation along the coastline, in some cases creating beach "carpets" up to 4 inches in thickness (UNESCO, 2007). More frequent and heavier rainfall events projected by climate models are likely to cause increased sedimentation, given the steep slopes of the island. This could lead to higher turbidity in areas surrounding the seagrass meadows, which would in turn smother the plants and block essential light.

3.11.3 Mangroves

Altogether, various studies have identified a combined total of fifteen (15) mangrove locations in the Federation, eight (8) in St. Kitts and seven (7) in Nevis (Bacon, 1993; Spalding et al, 1997). Fig. 18 shows the main mangrove locations in St. Kitts. The most recent estimates indicate that mangroves occupy a total area of 70 hectares in St Kitts and Nevis (FAO, 2005). Unfortunately, the stands at most sites are poorly stocked with only a few species represented. Greatheeds Pond and Friars Bay in St. Kitts, and Nisbett Settlement in Nevis are the only mangrove wetlands with

fairly extensive stands and several different species (FAO, 2005). *Avicennia germinans (black mangrove), Laguncularia racemosa (white mangrove), Rhizophora mangle (red mangrove)* and *Avicennia schaueriana, the latter listed on the 'IUCN Red List of Threatened Species', are the most widely occurring varieties.* White mangroves are mainly found in close proximity to fresh or brackish water ponds, although a few individuals of the species occur elsewhere (Bacon, 1993). The mangroves rarely exceed 5m in height, although at Greatheeds Pond black mangrove stands may reach as high as 10 m. The most common varieties on the island of Nevis are button (*Conocarpus erectus) and* white mangrove *(Jeffers and Hughes, 2002).* Like coral reefs, mangroves function as critical habitat and nurseries for many fish species and crustaceans, including high value catch, mainly lobster and conch that target the export market. They also help to trap contaminants landward of the coast, mainly nutrients, that would otherwise enter the marine area. Mangroves also help to attenuate wave action from high energy events generated by storms, hurricanes and northerly swells.

Regrettably, mangroves have been under severe stress for several decades now, owing primarily to widespread harvesting for fuel, the expansion of the tourism industry and other infrastructural development. This stress in now being compounded by additional risks posed by global climate change, which are already being observed in St. Kitts and Nevis. The principal stressors are sea level rise, higher SST, altered salinity and ocean acidification. *Rhizohopra mangle* is now virtually extinct on the island of Nevis, as only a few individual trees on Pinney's Beach are known to exist. As a result, the Nevis Historical and Conservation Society (NHCS) has embarked on a restocking project using *Rhizophora* seedlings imported from the neighbouring island of Antigua (**http://www.bio-diversity-nevis.org/mangrove_project.htm)**. Replication of such projects is highly recommended at the many degraded mangrove sites across the Federation to combat the combined threats posed by human activity and climate change. Unless consistent efforts are made to minimize the degradation of these valuable resources, through a combination strict enforcement of regulations, development control and habitat restoration, further declines in spatial extent, diversity and quality will continue to occur.

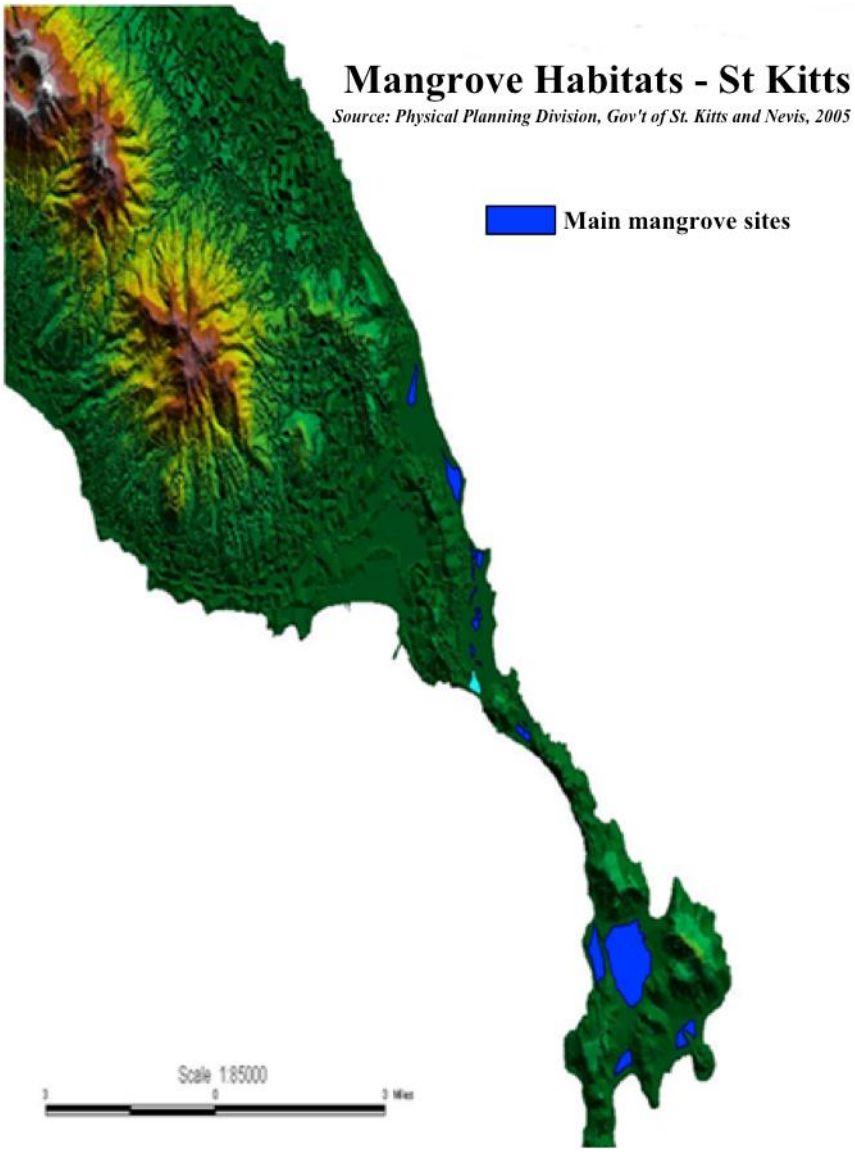


Figure 18 Mangrove locations in St. Kitts

3.11.4 Potential adaptation options for coastal and marine ecosystems

Given the vital role of costal ecosystems in the economic and social development of the Federation, greater emphasis must be placed on *protection* and *restoration* as key elements of an effective adaptation strategy. While the list of actions offered below for consideration is not exhaustive, the measures are considered viable, practical and cost-effective. Further, it is strongly suggested that serious consideration ought to be given to their urgent implementation:

- Implement the actions already identified in the 2004 National Biodiversity Strategy and Action Plan (NBSAP). The Plan has already been endorsed by the Federal Government and remains an important element of the country's ecological conservation policy.

- Update and implement the relevant activities contained in the National Environmental Action Plan (NEAP), all of which have already been agreed and endorsed by Government. Many of the strategies are excellent no-regret climate change response measures, and remain as relevant today as they were when the Plan was first published.

- Take action to reduce, restore and reverse where feasible coastal habitats in particular, coral reefs, mangroves and seagrasses. Protection from both marine and land-based sources of pollution and waste, both liquid and solid, should be considered a *sina qua non*. Stringent control of, and in some cases prohibition of injurious anthropogenic activities must also form part of this response. More effective land-use planning, abatement of contaminants and the application of relevant best practices are equally mandatory.

- Effective strategies, techniques and tools are now available for application in habitat restoration activities for corals, mangroves and seagrasses. Some of these are already being implemented in other jurisdictions in the Caribbean. For example, the development of coral nurseries on Laughing Bird Caye, Belize, the extensive, ongoing mangrove rehabilitation in Georgetown, Guyana, and seagrass transplantation experiments conducted in Barbados are a few examples that need to be carefully evaluated with a view to replication, once found to be viable and feasible. Restoration of these habitats will help to build resilience to the adverse effects of climate change, while ensuring the sustainability of the Federation's biodiversity and economic resource base.

- Where necessary, upgrade existing legislation and regulations relating to protection and conservation of ecological resources, ensuring in the process that effective, implementable enforcement mechanisms and sanctions are included.

- Embark on national public education programmes that embrace all stakeholders, using a variety of media, ensuring that all residents and visitors alike are fully seized of the vital importance of marine ecological resources to the sustainable development of the Federation.

3.12.0 Tourism, Settlement and Infrastructure

3.12.1 Tourism

As a small island state, St. Kitts and Nevis is extremely susceptible to sea level rise (SLR), given the high concentration of coastal infrastructure and the country's heavy dependence on coastal and marine assets as the primary basis of economic and social development. The magnitude of the sea level rise projections previously presented for the Federation, will clearly pose a severe threat to settlements and livelihoods, and the country's main industry, tourism, along with its associated infrastructure. Moreover, the severity of the threat will be amplified on account of elevated storm

surge heights, given an expected increase in the *intensity* of storms. The recently released IPCC Fifth Assessment Report points out that the rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia. The report also notes that over the period 1901 to 2010, global mean sea level rose by 0.19m [0.17 to 0.21], at a rate of approximately 1.7 mm $^{yr\text{-}1}$ (IPCC, 2014). The rate of increase has been most rapid in recent decades, as supported by the data for the period 1993-2010, when the rate of rise has been 3.2 mm year^{-1}, almost twice the long term average (IPCC 2014).

A previous study based on hypothetical sea level rise scenarios of 1m, 2m and beach erosion scenarios of 50m and 100m, gives a useful indication of the nature of the threat to critical resources and infrastructure in the Federation (Simpson et al, 2010 and 2012). The study projected that 67% and 77% of tourism properties would be at risk from sea level rise of 1.0 and 2.0 m, respectively (Ibid). It was further projected that if coastal recession of 100 m were to occur, 82% all resorts in St. Kitts and Nevis would be adversely affected, and 50% of air and sea port lands would be threatened by a 1.0 m rise in sea level (Ibid). It would also be extremely likely that the country's main settlements (e.g. Basseterre) and critical coastal road network would similarly be at great risk. Notwithstanding the weaknesses of applying the Bruun hypothesis as a tool in the analysis, the projections from Simpson et al (2012) likely represent a plausible picture of the future under the two scenarios selected. Clearly, these results would also imply that coastal damage especially from flooding and accelerated beach erosion would also be inevitable. Such eventualities would most certainly undermine the tourism resource base, and consequently threaten the sustainability of future national economic and social advancement.

3.12.2 Settlement and Infrastructure

Not unlike other small states in the Caribbean, most of the Federation's settlement and its critical social and economic infrastructure are sited within 0.5 km from the coast at 'normal' mean high water. The country is served essentially by one main highway that rings the coast, which is adjoined by a series of smaller secondary and tertiary roads. All critical infrastructure and the socio-economic activities that they support (tourism and recreation, port services, housing, education, health care facilities, trade and commerce and other services) follow this network, and for the most part are sited no further than a few hundred metres from the main coastal artery.

The threats of land loss from coastal erosion, sea level rise and storm surge currently pose severe challenges to St. Kitts and Nevis, and to that extent the safety and security of much of the country's infrastructure, economy and livelihoods are at great risk. Many of the threats to settlement and infrastructure have already been detailed in previous sections of this vulnerability assessment, especially in relation to sea level rise, the behaviour of storms and hurricanes and the sensitivity of the tourism industry. The seriousness of these combined threats are manifestly evident especially in the main settlements such as Basseterre on the mainland, and Charlestown in Nevis. These low-lying towns and their suburbs are at an elevation of <2.0 m *above mean sea level* (a.m.s.l), and are home to >50% of each island's population. The resulting high density of

population and infrastructure associated with these settlements enhances the economic and livelihood risks from hydro-meteorological hazards, whose frequency and intensity appear to be on the increase.

While the extent of flooding is difficult to predict, the combined results from climate change models that predict more intense rainfall episodes coupled with historic records of flood events, underscore the extent to which a warming climate is likely to exacerbate the effects of these phenomena. As the climate warms further and population and settlements increase, the spatial extent of these threats is very likely to increase. Nevis is similarly threatened, with many of the main roads intersected by watercourses and ghauts. It must therefore be of considerable concern that downscaled climate projections for the Federation suggest an increase in frequency and intensity of heavy rainfall events, which can only amplify flood risk.

3.12.3 Potential adaptation options in the settlement and infrastructure sector

Given the wide range of risks posed by climate change to infrastructure and settlement across St. Kitts and Nevis, a full suite of potentially efficacious, cost-efficient and environmentally sound options must be seriously considered. In all case, evaluation of the appropriateness of these measures should also be guided by the aims and objectives of Government's overall adaptation policy and priorities, as well as the social and cultural acceptability of the options. Against this background the following strategies are suggested for assessment and consideration:

- Relocation of critical settlements, economic and social activities and their supporting infrastructure from highly vulnerable locations (e.g. utilities, schools, segments of main road arteries where feasible) to areas of lower vulnerability and at higher elevation, and to regions less prone to storm surge, flooding and inundation. As part of this effort, enforcement of land use policies and controls that minimize risks posed by climate change would be mandatory. In this regard, instruments such as environmental impact assessments (EIAs) and social impact assessments (SIAs) would be valuable tools.

- Strict enforcement of building codes and standards, e.g. more hurricane resistant designs and structures. In other words, adoption of a culture of '*climate-proofing*' against extreme events such as storms and hurricanes. This should be considered an important, but ongoing initiative.

- Wider use of more appropriate architectural planning, e.g. the use of architectural designs that provides more efficient natural ventilation, as a response to elevated temperature and the increased risk of heat stress.

- Given the continuing annual threat of damage to infrastructure from high energy events such as storms and hurricanes, urgent consideration should be given to wider use of underground cables and utility lines, and other appropriate low-risk system. Such policies are already being implemented in other Caribbean jurisdictions.

- Wider adoption and more judicious application of proven, effective, 'traditional' technologies and knowledge. Many vulnerable island communities have had to adapt to weather- and climate-related hazards for generations, and in some cases have accumulated skills and 'know-how', which (although considered 'low-tech') have proven to be effective in the past. Examples include (i) the construction of the traditional *hipped roof* (four-sided) which is resistant to wind damage, including from extreme events like storms and hurricanes (ii) construction of houses on elevated structures or 'stilts' in low-lying, flood-prone areas as has been practiced widely in Guyana and Belize for generations; and (iii) more effective use of trees and shrubs to provide shade, a practice that has been successfully adopted in many Pacific island countries. This simple, inexpensive strategy has been shown to reduce internal heat and contribute to more comfortable human habitation of houses and other buildings.

Where appropriate, desirable and affordable, the purchase of insurance can be a tool for sharing and spreading risks, and reducing future loss that will inevitably arise as a consequence of global climate change. Obviously, cost could be a major constraint, as insurance and reinsurance companies tend to charge high premiums for coverage in high risk locations.

3.13 The Water Sector

In St. Kitts, most of the potable water is sourced from 28 groundwater wells which are naturally recharged by rainfall, and 7 surface springs which provide 70% and 30% of the Federation's water needs respectively (MPWUTP, 2010). Most of the water consumed in Basseterre, the largest urban centre and capital of the Federation, comes from a single source - Wingfield, the largest of the springs.

All residents of St. Kitts have access to water 24 hours per day from the municipal supply, all of which is sourced and distributed by the St. Kitts Water Service Department (WSD). A 2007 study found that only 4.2% of households and 2.9% of individuals had poor access to water, i.e. they did not have access to piped water. On average for both St. Kitts and Nevis, 96.8% of the population has access to potable water. The domestic sector consumes > 50% of the water supply, while consumption in each of the tourism, agriculture and commercial sectors accounts for between 10 and 15% of the country's total water supply. While there is sufficient water to meet current needs, it should be noted that overall demand is increasing, most noticeably in the tourism sector.

Desalinization is not a source for the municipal supply, however the Marriott resort operates a privately owned facility that produces 1.25 mgd to meet the hotel's water requirements. Groundwater produced from 14 active wells is the main source of supply in Nevis (USACE, 2004). When compared with mainland St. Kitts, however, Nevis is considered to be much less endowed, owing to the lower elevations, lack of major springs, and the existence of a significant silica pan overlain by clay soils that reduce infiltration rates (MHE, 2001). The average annual rainfall in Nevis is 1,170 mm, which is considerably lower than in St. Kitts. As a result, many residents often

resort to storage of rainwater in cisterns to augment supply. Although the island can meet current demand, most of the wells in Nevis are considered to be producing near peak capacity. Desalination is not currently used to supplement resources in Nevis. Notwithstanding the small population (just over 12,000 persons), water consumption is estimated to be around 1.0 mgd, mainly due to the high demand from the tourism sector.

The water resources sector in St. Kitts and Nevis is vulnerable to climate change in a number of ways. Sea level rise can contaminate coastal aquifers through saline intrusion, and hurricane activity can adversely impact water infrastructure. Given recent climate model projections for a drier St. Kitts and Nevis and a shorter rainy season, water resources managers will be confronted with serious challenges. Currently during the dry season the WSD and the Nevis Water Department restrict water usage, and the island also appears to have adjusted to the practice of rainwater harvesting. This is noted in a CEHI (2006) study, which shows that while 80 – 90% of residents and businesses in Nevis have facilities for engaging in rainwater capture, only 5% of residents in St. Kitts are similarly equipped.

All of the groundwater resources from St. Kitts are sourced from coastal aquifers. Not surprisingly, with between 65 - 70% of all water sourced from groundwater, the St. Kitts WSD is beginning to observe early signs of salinity intrusion from its monitoring programme (Sahely et al., 2010). This has prompted two responses, namely (i) abandonment of one of the wells and (ii) introduction of metering as a strategy to reduce unnecessary consumption and waste. The elevation of coastal aquifers in Nevis is about 2 m, but may reach as high as 70 m in the mountainous zones. In coastal areas the freshwater-saltwater interface is assumed to be located at roughly 20 m (USACE, 2004). Given the small size of Nevis and the closeness of all locations to the sea, saline intrusion is a real concern and an almost certain reality.

3.13.1 Potential adaptation options in the water resources sector

Potentially effective, viable and locally appropriate climate change response strategies that may be considered in the water sector include:

- Optimization of the existing supply through, for example, installation of meters, replacement of leaking mains; rainwater harvesting from roof catchments, and storage in cisterns (as is practiced in the Grenadine Islands).

- More extensive application of recycling, e.g. the use of grey and partially treated water for non-potable purposes such as landscaping, irrigation of golf courses, etc.

- Investment in more efficient and extensive water storage facilities (e.g. reservoirs), as an augmentation measure, which would also help to cushion the immediate adverse effects of scarcity during dry spells and protracted droughts.

- Consistent and wider adoption of proven water-saving technologies, e.g. low-flush toilets and faucets that automatically shut off water when not in use, along with the provision of appropriate incentives.

- Artificial recharge of aquifers may also be considered. However, this requires the application of technical knowledge and skill in execution to ensure that external contamination is not introduced to the aquifer.

- Desalination is a proven, though potentially costly technology that can be used to augment reduced water supply. However, appropriate management of the waste generated (brine) should be determined prior to implementation. Moreover, desalination typically requires a high energy input and could therefore become counter-productive as a climate change adaptation option, if hydrocarbon-based energy is used. There is now great potential for operating reverse osmosis plants using renewable energy sources. The desalination plant commissioned in Bequia under the SPACC project executed by the Caribbean Community Climate Change Centre is an excellent example of a successful operation whose GHG emissions are virtually zero. It is powered by a grid-tied solar photovoltaic system.

- In some instances, it may be possible to import water from locations where there is a surplus available for sale. Prior to the construction of the desalination facility on Bequia, the island obtained potable water by barge from mainland St. Vincent.

3.14 Agriculture and Food Security

St. Kitts and Nevis, like many other countries in the Caribbean, has been historically dependent on the sugar cane industry, which had formed the basis of the economy. However, with changes in international trading regimes, and competition from larger sugar producing countries, the Government decided to close the state-owned St. Kitts and Nevis Sugar Manufacturing Corporation (SSMC) in 2005. Sugar cane production, which stood at 400,000 tonnes in 1955, had declined to just under 150,000 tonnes in 2005. The industry was a major contributor to the Government's fiscal deficit, with annual losses equivalent to 4% of GDP (European Commission, 2007). According to a study on agriculture and Food Security in the Eastern Caribbean Currency Union (Labadie, 2008), the agricultural sector in St. Kitts and Nevis is still recovering from the closure of the sugar industry. The contribution of the agricultural sector to GDP has registered a steady decline from 15.6% in 1980 to 5.2% in 1999 and 4.85% in 2003. Presently, the contribution of agriculture to national GDP is around 3.5%.

The Nevis Island Administration (2010), reports that in 2009 agriculture contributed EC $27.53 million to GDP for the twin island Federation, a contraction of 8.05% over the previous year. The national strategy promotes diversification into non-sugar crops, with one of the stated aims of government policy being to provide opportunities for retraining of former sugar workers, so as to

equip them for new agricultural opportunities. The majority of crop farming in St. Kitts and Nevis is dominated by small farmers with the average size of holding <1.0 ha. Larger farmers have holdings of up to about 5 hectares. As a consequence of the policy of diversification, the ability of farmers to meet a substantial portion of the demand for local produce has been enhanced. The provision of vegetables such as tomatoes, green peppers and pumpkin in 2009 was enough to meet 37.20% of the total national demand. In addition, the re-introduction of the production of Sea Island cotton on the island of Nevis in 2008 has further boosted agro-industry productivity. In the 2008/2009 period the Cotton Producers Association exported 9,500 pounds of cotton to Japan earning significant foreign exchange for the Federation. The sector has also benefitted from the commissioning of a new agro-processing plant in 2009 at Prospect Industrial Site in Nevis. The initiative is expected to increase the economic value added to agriculture and provide new products for export.

The Eastern Caribbean Central Bank (2011) reports that except for the agricultural sector, all other areas of the economy of St. Kitts and Nevis are estimated to have contracted in the period January to September 2010 compared with the performance in the corresponding period of the previous year. Higher output in the sector was driven mainly by a higher level of production in the crop and fisheries sub sectors, which rose by 13.3% and 10.0%, respectively.

Although there has been increasing production in the agricultural sector in recent years, climate projections based on results from the HadCM2 model suggest that by the second quarter of the Century, conditions may be too dry to support for rain-fed agriculture, and yields would likely fall below economically viable levels. In this scenario, sugarcane cultivation would only be possible in irrigated conditions for which, the same model suggests there would be inadequate water. In the case of livestock, fruit and vegetable production, projections based on HadCM2 suggest that future prospects would be bleak. In Nevis, rising sea levels are likely to lead to salinisation of agricultural soils in lowland areas, and in both islands salinisation of coastal aquifers, which is already being observed, will adversely impact water availability for agriculture. Discussions at the 15th Annual Agricultural Review and Planning Meeting held on March 9, 2010 appear to support the validity of the HadCM2 projections. Farmers reportedly noted that the harsh and long dry spells frequently experienced by farmers across the Federation was making production more difficult. In the last quarter of 2009 vegetable production was adversely affected by heavy and consistent rainfall. This reduced the time available for land preparation considerably, and consequently led to a loss of *planting days* for farmers.

3.14.1 Potential adaptation options in agriculture

As in other sectors, adaptation strategies in the agriculture sector will have to be configured in a manner that would render them compatible with Government's plans and overall strategy for the sector. The following options are proposed for further study and consideration:

- Where feasible and desirable, susceptible crops may be replaced by new genotypes that would be better adjusted to a changed environment, as a consequence of climate change. These may include the introduction of *halophytes* or salt-tolerant crop varieties in areas already experiencing or threatened by salinity intrusion; *hydrophytes* or species that can tolerate excess water in areas prone to flooding; *xerophytes* or drought-resistant crop; and species that may be better adapted to higher temperatures, in which case critical processes such as flowering which affects yields would not be seriously impaired.

- In extreme cases, consideration may have to be given to abandoning unproductive lands on account of changed conditions e.g. due to excessive salinity, extreme dryness or desertification, as a consequence of climate change.

- Introduction of crop varieties that are more resistant to insects and other pests whose population may increase on account of changed climatic conditions. In this case, more selective and/or extensive application of chemical controls, or the use of appropriate biological controls may be additional options.

- Implementation of water-based & water protection farming technologies, e.g. in areas of increasing dryness, use trickle irrigation instead of systems that irrigate less efficiently.

Some opportunities and potential may also exist for experimenting with appropriate *intervention programmes*, e.g. *captive breeding* to ensure the survival of plants and animals whose viability or survival may be threatened under a changing climate.

3.15 Fisheries

Though contributing <2.0% of GDP, artisanal and commercial fisheries are a vital component of the Federation's economy. Although catch rates have been on the decline, e.g. falling from 626 tons in 1990 to 257 tons in 2000 (CIA, 2014), these activities support national food security by providing an important source of protein, while supporting full- and part-time employment that support many families. Total catch is insufficient to meet local needs, resulting in the importation of salted, dried, smoked and frozen fish from North America.

Analysts suggest that some of the decline in the industry is due to overfishing and other unsustainable practices, habitat degradation and pollution IPCC, 2007; Oxenford et al, 2008). Irrespective of the combination of anthropogenic factors that might be responsible for the decline in the local fisheries output, there is no doubt that climate change and its associated threats will further undermine the sustainability of the industry (IPCC, 2007 and 2014; Pulwarty et al, 2008; Allison et al, 2009; Nurse, 2011). Sustained risks will eventuate via a suite of climate-related processes, including coral bleaching and ocean acidification.

The risk posed by climate change to critical fisheries-dependent coastal habitats (coral reefs, seagrasses and mangroves) has been discussed in earlier sections of this assessment. These risks combined with the reality of elevated SSTs, sea level rise and more intense storms will adversely impact 'normal' operations in the industry, including time spent at sea, availability of market and boat repair sites and even coastal settlements where many fishers reside.

3.15.1 Potential adaptation options in the fisheries sector

There are a number of possible adaptation strategies that can be successfully applied to build resilience in the fisheries sector. These include, but are not limited to the following:

- Development of fisheries management plans and techniques appropriate to the changing environment, e.g. adoption of more appropriate harvesting methods as a result of change in species; changes in abundance may also require the imposition of catch limits and closed seasons.
- Ensuring that critical fish habitats, in particular coral reefs, seagrasses and mangroves are protected by for example, reducing physical damage and contaminant loading. The establishment of protected areas is a tried and tested strategy that has been applied successfully elsewhere in the Caribbean. Habitat restoration can constitute a component of these activities.
- Conducting and updating *stock assessments* as important tools for managing fisheries resources under changing conditions (due to climate change impacts). Conducting these assessments will provide a good inventory of available species that can be used as a tool for identification of over- and under-exploited stocks.
- Implementation of education programmes on the implications of climate change for the sector, ensuring that the components of the programme are appropriately configured to reach key, targeted stakeholders, e.g. fishers and fisheries managers.
- Ensuring that coastal protection and other adaptation measures do not adversely affect fisheries resources.
- Exploration of possibilities for retraining and alternative livelihood opportunities for fishers and others directly dependent on the sector for livelihood support.

3.16 Forestry

The Federation of St, Kitts and Nevis retains one of the highest percentages of forest cover in the Caribbean. However, as in most countries of the Caribbean, there is much evidence of human disturbance of the forest ecosystem. Intensive land clearance in the low elevation zones has

removed all of the original forest cover and most of the other vegetation assemblages. Most of the forest cover occurs along the higher slopes and mountain peaks, while shrubs and grasses predominate on the lower slopes. Beard (1946) recorded some 243 tree species, including two ecologically important endemics, marmee apple or manciport (*Mammea americana*) and the cacanda, crackanga, or cracanda, which are both endangered on account of human activity. The forest also provides habitat for many species of fauna, including the green vervet monkey (Jeffers and Hughes, 2003).

Forests account for an estimated 11,000 ha, representing 42.3% of total land area (St. Kitts and Nevis Country Profile, 2011). Forestry is also a vital economic and development sector, providing a variety of critical ecological functions (e.g. climate regulation, carbon sequestration, soil and water protection), as well as timber and related products. In addition, much of the world's tourism is dependent on biodiversity, both flora and fauna. In St. Kitts and Nevis, the sub-sector has traditionally played an important role in livelihood development, and more recently has contributed to the eco-tourism product, by for example providing locations for hiking and nature trails (e.g. Nevis Peak, Butler's Source and Jessups, *inter alia*).

Present anthropogenic threats to the forest ecosystem arise mainly from deforestation, extraction for fuel, and uncontrolled burning as a method of clearance to support crop cultivation. But it is anticipated that these stressors will be exacerbated by projected decreases in rainfall, more protracted dry seasons, a higher number of '*hot*' and '*very hot*' days (i.e. days on which maximum temperatures reach or exceed 30^0 C and 35^0 C respectively), and a higher incidence of drought. This could lead to a contraction of the rainforest in favour of a greater spatial extent of tropical dryland species. In addition, while such an eventuality could reduce the diversity of product attractions in the tourism industry, some of the critical ecological functions identified above would also be lost.

3.16.1 Potential adaptation options in the forestry sector

As in other sectors, consideration will have to be given to a suite of strategies in this sub-sector, if the ecological integrity of the country's forest reserves. Some potentially efficacious options offered for consideration include:

- Stringent adherence to the principle of maintaining sustained yields, as a strategy for ensuring that species balance is maintained, and the rate of extraction does not exceed the rate of natural forest regeneration. In this context, considerable attention should be paid to the preservation and maintenance of species *endemicity*, *variety* and *uniqueness*, in order to minimize potential biodiversity losses that could eventuate as a result of changes in climate.

- Reforestation of lands previously cleared for other land uses back to forest.

- Conversion of lands not historically (or in the recent past) under forest, to forest regimes (afforestation).

- Preservation of balance between native and non-native species, as a further measure to maintain high endemicity.

- Application of alternate and more efficient harvesting methods, with a view to minimizing (i) damage to species not being targeted for extraction; and (ii) waste from logging operations, so that production of both timber and non-timber products can be optimized.

3.17 Human Health

The health status of any community is not only conditioned by direct exposure to illness, but is also partly determined by the availability and quality of primary and secondary care, and a variety of economic, social and environmental factors, among others. The range of threats posed by climate change and climate variability to the social and economic development of St. Kitts and Nevis must therefore be cause for concern, as these will simultaneously exacerbate existing health risks and increase exposure to new and emerging challenges. The IPCC has demonstrated in various assessments, including the recently released Fifth Assessment Report, that human safety and well-being will worsen as a direct consequence of climate change. This would be largely attributable to changes in the character of "*extreme climate events"*, in particular floods, droughts and storms (IPCC, 2001, 2007, 2014).

According to the World Health Organization (WHO, 2003), the Caribbean region is highly vulnerable to a large number of climate-sensitive illnesses, whose prevalence is expected to increase with projected changes in climate. The WHO categorized the illness into the following groups:

i. Insect- and rodent-borne diseases: dengue, malaria, yellow fever and leptospirosis;
ii. Water-borne diseases: schistosomiasis, cryptosporidium and cholera;
iii. Food-borne diseases: diarrhoeal illnesses, food poisoning, salmonella and typhoid;
iv. Respiratory diseases: asthma, bronchitis, and respiratory allergies and infections; and
v. Malnutrition resulting from disruption of food production or distribution.

The Federation of St Kitts and Nevis has already been shown to be highly exposed to the passage of tropical storms, hurricanes and other weather extreme such as heavy rainfall events. Consequently threats to the health sector will be both *direct* (e.g. due to physical injury, higher morbidity and mortality, damage to health infrastructure such as hospitals and clinics) and *indirect* (e.g. through loss of and reduced access to water and food, poor sanitation and hygiene, creation of favourable environments for vector and non-vector borne disease transmission). Many of the Federation's primary care facilities including the J. N. France and Alexandra hospitals are located in vulnerable, low-lying areas that are prone to both terrestrial and marine flooding. Increased

frequency and/or intensity of events that are capable of reducing the operational capacity of these facilities will evidently have severe implications for the health status of local communities.

Flood and drought are also known to pose serious risks to human health globally, but especially in developing countries where resources to respond to these events are often inadequate. Damage to water and sewerage infrastructure and contamination of supply from excess runoff and floodwaters (e.g. after passage of a tropical storm or hurricane) can reduce the quality and quantity of water available for potable and personal hygiene purposes. Similarly, a lack of or reduced quantities of potable freshwater that often accompany episodes of drought can be equally challenging for the health sector, as such circumstances can cause sanitation and hygiene standards to be severely compromised.

With projected increases in mean, minimum and maximum temperatures across the Federation up to the end of the Century, acceleration in the number of cases of heat stress is a very likely outcome. The very young and the very old will be susceptible to the effects of increased temperature with heat exhaustion and dehydration being major problems. With a higher incidence of '*hot*' and '*very hot*' days projected before mid-Century, an increase in the occurrence of such heat-related illnesses would be almost inevitable.

In a detailed study of dengue fever in the Caribbean, Chen et al (2006) indicated that disease transmission rates would increase on account of the projected 2 ^{0}C increase in temperature across the region, by the end of the Century. They noted that the *abundance* of vectors (*Aedes aegypti* mosquito) and *transmission rate* of the disease are both modulated by temperature and rainfall, and that a temperature increase of 2 ^{0}C (e.g. from 30 ^{0}C - 32 ^{0}C) would shorten the incubation period of the viruses from 12 to 7 days for dengue type 2. The analysis concluded that a reduction of the incubation period by 5 days can lead to a 3-fold higher transmission rate of dengue. These findings must be of some concern to St. Kitts and Nevis, where dengue fever is now endemic), with 305 confirmed cases in the Federation between 1995 and 2000 (MOE, 2001; PAHO, 2008). During this period there were 19 cases per year, but the number of confirmed cases increased to 26 cases per year in the following 10 years. Most of the confirmed cases have occurred in St. Kitts. Between 2005 and 2010, there were 113 cases in St. Kitts and 7 in Nevis (Ministry of Health, 2011). In the Chen et al (2006) study it was also shown that outbreaks of dengue are often seasonal, with most cases tending to occur the 'normal' wet season. This is borne out by the most recent statistics for the Federation where in 2010, of the 16 cases of dengue reported, only 1 was recorded in February (dry season), with the other 15 cases recorded in the wet months of June, July, September October and November (Ministry of Health, 2011).

3.17.1 Potential adaptation options in the health sector

Minimizing risk and building resilience to climate change in the health sector will be quite challenging for a small, vulnerable, resource-scarce nation like St. Kitts and Nevis. For adaptation

in this sector to be effective, societal, institutional, technological and behavioural changes will be required. Such changes must occur at the national, community and personal levels.

The following portfolio of strategies are offered for consideration:

- Enhancement and expansion of existing *primary* and *secondary* care facilities and systems, as a critical component of disease prevention and management. Primary prevention would contribute to a reduction in health risks before outbreaks (e.g. disease) occur; a critical role of *secondary* intervention would be to prevent further cases. Implementation of ongoing programmes in human resources training, surveillance, prevention and control should be considered vital components of the strategy. The training and public education programmes should be targeted to reducing the risk of disease exposure and transmission, and improving disaster management plans so as to enhance emergency preparedness.

- Adoption and wider use of protective technologies and systems, e.g. water purification; enforcement of quality standards for potable water.

- The WHO has demonstrated that the implementation of *Health Early Warning Systems* (HEWS) and *epidemic forecasting* can be useful in the forecasting and detection of environmental conditions favourable to the outbreak of climate-sensitive diseases such as dengue, which is endemic in the Federation.

- Improvement and maintenance of cost-efficient, environmentally-sound sewage and solid waste management systems and related initiatives, e.g. more extensive application of sewage treatment, implementation of improved solid waste management systems including collection and disposal, and the relocation of landfills from flood-prone and other vulnerable locations.

References

Agostini, V. N., Margles, S. W., Schill, S. and Blyther, R. J. (2010). Marine Zoning in Saint Kitts and Nevis: A Path Towards Sustainable Management of Marine Resources. Florida, USA: The Nature Conservancy.

Allison, E.H., Perry, A.L., Badjeck, M.C., Adger, W.N., Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L., and N. Dulvy. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries* 10: 173–196.

Bacon, P.R., 1993. Mangroves in the Lesser Antilles, Jamaica and Trinidad and Tobago. In: Lacerda, L.D. 1993. Conservation and sustainable utilization of mangrove forests in Latin America and Africa regions. Vol. 2 Part I- Latin America, 155 210. Mangrove Ecosystem Technical Reports ITTO/ISME Project PD114/90 (F). Okinawa, Japan. 272 pp.

Beard, J. S. 1949. The natural vegetation of the Windward and Leeward Islands. Oxford Forestry Memoirs 21. Clarendon Press, London. 192 pp.

Bengtssen L., K. I. Hodges, M. Esch, N. Keenlyside, L. Kornblueh, J-J Luo & T. Yamagata, (2007). How may tropical cyclones change in a warmer climate? *Tellus Series A-Dynamic Meteorology and Oceanography*, 59(4), 539-561.

CEHI. (2006). Programme to Promote Rainwater Harvesting in the Caribbean Region. Castries Caribbean Environmental Health Institute, pp. 38

Chen, A. A., Chadee, D. D., & Rawlins, S.C. (2006). Climate Change Impact on Dengue: The Caribbean Experience: Climate Studies Group Mona, University of the West Indies.

Church, J., White, N., Coleman, J., Lambeck, R., & Mitrovica, J. (2004). Estimates of the regional distribution of sea-level rise over the 1950-2000 period. *Journal of Climate*, 17, 2609- 2625.

CIA, 2014. World Factbook updates.

Cooper, V. (2001). Inland Flood Hazard Assessment and Mapping for St. Kitts and Nevis: Post-Georges Disaster Mitigation Project in Antigua & Barbuda and St. Kitts & Nevis. St. Augustine: Organisation of American States Unit for Sustainable Development and Environment, USAID - Jamaica/Caribbean Regional Program. Eastern Caribbean Central Bank. (2011). *Economic and Financial Review*. pp. 41 – 48.

ECLAC. (2003). Review of the Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States (SIDS POA) in the Caribbean Sub-region. Port of Spain: Economic Commission for Latin America and the Caribbean.

Elsner, J. B., J. P. Kossin, and T. H. Jagger (2008), The increasing intensity of the strongest tropical cyclones, *Nature*, 455(7209), 92–95, doi:10.1038/nature07234.

Emanuel, K., R. Sundararajan and J. Williams. (2008). Hurricanes and global warming - Results from downscaling IPCC AR4 simulations. *Bulletin of the American Meteorological Society*, 89(3), 347-367.

European Commission Directorate. (2007). Annual Operational Review St. Kitts & Nevis. Joint Annual Report 2006. Report No. C1*4 D 2007 6303. Brussels: Commission Européenne.

Global Facility for Disaster Reduction and Recovery (GFDRR), 2010. Disaster risk management in Latin America and the Caribbean Region. World Bank, 276 pp.

Hoegh-Guldberg, O, Mumby PJ, Hooten AJ, Steneck RS, Greenfield P, Gomez E, Harvell CD, Sale PF, Edwards AJ, Caldeira K, Knowlton N, Eakin CM, Iglesias-Prieto R, Muthiga N, Bradbury RH, Dubi A, Hatziolos ME (2007) Coral reefs under rapid climate change and ocean acidification. *Science*, **318**(5857), 1737-1742.

Holland, G. J. and P. J. Webster, 2007: Heightened tropical cyclone activity in the North Atlantic: natural variability or climate trend? *Phil. Trans. R. Soc. A* doi: 10.1098/rsta.2007.2083 (pdf)

Intergovernmental Panel on Climate Change(2000) Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, U.K., 599 pp.

IPCC (2001) Climate change 2001: impacts, adaptation, and vulnerability: Contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 1033 pp.

Intergovernmental Panel on Climate Change (2007) Climate change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II Contribution to the Fourth Assessment Report of the IPCC. Cambridge University Press, 976pp.

Intergovernmental Panel on Climate Change, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC, 2014: Summary for Policymakers. In: Climate Change 2013: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jeffers, R. and Hughes, J., 2003. Sustainable use of the coastal zone: Using economic incentive mechanisms to promote adaptation to Climate Change in the Hotel Sector, St. Kitts and Nevis. 39 pp.

Kossin, J. P., Knapp, K., Vimont, D. J., Murnane R. J. & Harper, B. A. (2007): A globally consistent reanalysis of hurricane variability and trends. *Geophysical Research Letters*, 34(4), 6.

Knutson, T. R., Sirutis, J. J., Garner, S. T., Vecchi, G. A. & Held, I. M. (2008). Simulated reduction in Atlantic hurricane frequency under twenty-first-century warming conditions. *Nature Geoscience* 1(6), 359-364.

Labadie, B. (2008). Agriculture and Food Security in the ECCU. St. Kitts: Eastern Caribbean Central Bank.

Marcello, G. (2011). After Hurricane Omar, Four Seasons is Back. The St. Kitts Nevis Observer No.855. Retrieved 1/11/2011, from: http://www.thestkittsnevisobserver.com/2011/03/18/four-seasons.html.

MHE. (2001). National Report Integrating the Management of Coastal Wetlands in St. Kitts and Nevis (pp. 42). Basseterre: Department of the Environment, Ministry of Health and the Environment, Government of St. Kitts and Nevis.

MOE (2001). St. Kitts-Nevis Initial National Communication. Basseterre, St. Kitts-Nevis: Ministry of Environment, Government of St. Kitts Nevis.

MOSD. (2007). National Action Programme for Combating Desertification and Land Degradation: In the Context of the United Nations Convention To Combat Desertification. Basseterre: Department of Physical Planning and Environment, Ministry of Sustainable Development, Government of St. Kitts and Nevis.

Munday PL, McCormick MI, Nilsson GE (2012) Impact of global warming and rising CO_2 levels on coral reef fishes: what hope for the future? *Journal of Experimental Biology*, **215**, 3865-3873.

Nevis Island Administration. (2010). Prospectus for 365- days Treasury Bill. Nevis: Ministry of Finance.

Nurse, L., 1993. A proposal to construct a resort (Hyatt Regency) at Friar's Bay, St. Kitts: An evaluation of coastal and marine impacts. Prepared for Ivor Jackson and Associates, 13 pp.

Nurse, L.A, 1993. Coastal and marine impact assessment of the proposed Banana bay Club Hotel and village, Banana Bay, St. Kitts. Prepared for Ivor Jackson and Associates, 15 pp.

Nurse, L.A., 1994. Marine and coastal impact evaluation of a proposed resort complex, North Frigate Bay, St. Kitts, 17pp.

Nurse, L. 2011 The implications of global climate change for fisheries management in the Caribbean. *Climate and Development* 3 (3): 228-241.

OAS-USAID, 2001. St. Kitts and Nevis Hazard Vulnerability Assessment: Final Report. Post-Georges Disaster Mitigation Project in Antigua & Barbuda and St. Kitts & Nevis, 42 pp.

Oxenford H, Roach R, Brathwaite A, Nurse L, Goodridge R, Hinds F, Baldwin K, Finney C (2008a) Quantitative observations of a major coral bleaching event in Barbados, south-eastern Caribbean. *Climatic Change*, **87**, 435-449.

PAHO (2008). Health Systems Profile St. Kitts and Nevis, Monitoring and Analyzing Health Systems Change/Reform (pp. 38). Bridgetown: Area of Health Systems and Services HSS-SP, Office of Eastern Caribbean Cooperation, Pan American Health Organisation/World Health Organisation.

Pulwarty, R., Nurse, L., Trotz, U., 2010. Caribbean islands in a changing climate. *Environment: Science and Policy for Sustainable development*, 52(6), 16-27.

Rodríguez S, Cróquer A, Bone D Bastidas C (2010) Severity of the 1998 and 2005 bleaching events in Venezuela, southern Caribbean. *Revista de Biología Tropical*, **58**, Suppl., 3189–196.

Sahely, H, Nettles, S, Burrowes, R, & Haas, G. (2010). Combining sound science, legal action and stakeholder involvement to protect a vulnerable coastal aquifer on the island of St. Kitts. Paper presented at the Caribbean Environmental Forum 5, Montego Bay, Jamaica. Basseterre.

Simpson, M. C., Clarke, J. F., Scott, D. J., New, M., Karmalkar, A., Day, O. J., Taylor, M., Gossling, S., Wilson, M., Chadee, D., Stager, H., Waithe, R., Stewart, A., Georges, J., Hutchinson, N., Fields, N., Sim, R., Rutty, M., Matthews, L., and Charles, S. (2012). CARIBSAVE Climate Change Risk Atlas (CCCRA) - Nevis. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies

Simpson, M. C., Scott, D., Harrison, M., O'Keeffe, E., Sim, R., Harrison, S., et al. (2010). Quantification and Magnitude of Losses and Damages Resulting from the Impacts of Climate Change: Modelling the Transformational Impacts and Costs of Sea Level Rise in the Caribbean (Summary Document). United Nations Development Programme (UNDP), Barbados, West Indies.

Spalding, M., F. Blasco and C. D. Field (Eds.), 1997. *World Mangrove Atlas.* The International Society for Mangrove Ecosystems, Okinawa, Japan, 178 pp.

UNESCO. (2007). Beach Erosion in Nevis. Retrieved 15/07/2011, from Environment and development in coastal regions and in small islands: http://www.unesco.org/csi/act/cosalc/theme11.h

USACE. (2004). Water Resources Assessment of Dominica, Antigua, Barbuda, St Kitts and Nevis. Mobile, Alabama: Mobile District and Topographic Engineering Center, US Army Corps of Engineers. pp. 95.

USACE. (2004). Water Resources Assessment of Dominica, Antigua, Barbuda, St Kitts and Nevis. Mobile, Alabama: Mobile District and Topographic Engineering Center, US Army Corps of Engineers. pp. 95.

Vecchi, G. A. & B. J. Soden, (2007): Effect of remote sea surface temperature change on tropical cyclone potential intensity. *Nature*, 450, 1066-1070.

Webster, P. J., G. J. Holland, J. A. Curry, and H.-R. Chang, 2005. Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. *Science*, 309, 1844–1846.

Chapter 4 Technology Needs Assessment

This chapter should be read in conjunction with the chapter on mitigation and abatement. St. Kitts and Nevis conducted a comprehensive technology needs assessment for climate change (TNA) in 2005 according to the prescribed methodology[3] at that time. The main findings of the TNA included:

In the context of mitigation (across relevant sectors):

- Micro-scale hydro;
- Solar;
- Wind power;
- Biomass and Cogeneration;
- Combine cycle gas turbines;
- Geothermal energy;
- Demand-side management;
- Bi-fuel vehicles;
- Conversion of existing vehicles to bi-fuel systems by installing conversion kits for the use of compressed natural gas (CNG);
- Flexible fuelled vehicles;
- Electric vehicles;
- Hybrid vehicles;
- Fuel cell vehicles (FCVs);
- Energy efficient appliances;
- Energy saving lamps (fluorescent vs. incandescent);
- Solar technology (water heating and air-conditioning);
- Energy efficient building designs in future housing developments;
- Time of use devices for switching on and switching off appliances.

In the context of adaptation (across all relevant sectors):

- Domestic water conservation technologies such as water efficient faucets, toilets and showerheads;
- Irrigation technologies including sprinkler systems and drip irrigation;
- Rainwater harvesting;
- Technologies for soil and water conservation (also applicable to the agricultural sector) such as storage ponds;
- Desalination (potentially costly option);
- Early warning systems for forecasting of wet and dry periods;
- Adoption of drought-resistant cultivars;
- Geographical Information Systems (GIS);
- Change of sowing and harvesting periods;

[3] Gross, R., Dougherty, W., and Kumarsingh, K. (2004) "Conducting Technology Needs Assessments for Climate Change" UNDP, New York, US, 26 pp July 2004

- Pesticide application technologies and practices;
- Integrated Pest Management (IPM) systems and practices;
- Soil management technologies and practices;
- Aquaculture and mariculture technologies;
- Deployment of fogging machines for vector spraying;
- Use of insecticide-treated nets;
- Integrated vector management systems (IVM) (process for managing vector populations in such a way as to reduce or interrupt transmission of disease).

The study also identified the nexuses and synergy across sectors for technology applications as summarised in the table below.

Table illustrating the nexuses and synergy across and among sectors for technology application

Sector	Energy	Road Transport	Forestry & Terrestrial Ecosystems	Coastal Ecosystems	Water Resources	Agriculture	Human Settlements	Human Health	Tourism
Energy		√				√	√		√
Road Transport	√							√	
Forestry & Terrestrial Ecosystems				√	√	√			√
Coastal Ecosystems			√		√	√	√		√
Water Resources			√	√		√		√	√
Agriculture	√		√	√	√			√	√
Human Settlements	√			√				√	√
Human Health		√			√	√		√	√
Tourism	√		√	√	√	√	√	√	

The TNA significantly identified cost, policy and legislative issues related to creating the enabling environment as barriers to successful deployment of identified potential technologies. It also recommended a comprehensive policy and legislative review in order to further identify such barriers and subsequently, technology priorities. A more recent methodology for conducting technology needs assessments for climate change[4], developed by the UNDP and the UNFCCC suggests and approach which focuses on climate change technology to achieve sustainable development, and therefore in line with the country's development strategies. This chapter therefore builds on TNA report in the context of the approach identified in the recent methodology. As the technologies identified in the TNA are still relevant, this chapter narrows the focus of these technologies in the context of the development policies (sectoral and national) for St. Kitts and Nevis.

4.1 Mitigation

The chapter on mitigation and abatement has already identified policy issues related to mitigation. The following sections therefore focuses on these policy issues in narrowing the scope of possible technologies and associated technology priorities.

Energy Sector (including power generation and transportation)

An analysis of the energy sector[5] in St. Kitts and Nevis suggests that "*wind and bio-energy project on St. Kitts will not produce enough electricity to meet future demand and to compensate the declining conventional electricity supply. The deficit in the medium growth scenario amounts to -12 MW in 2012, -20 MW in 2016 and -35 MW in 2020. The wind and geothermal projects on Nevis by comparison, will result in a significant electricity surplus even with increasing demand and declining conventional capacity. The surplus in the medium growth scenario amounts to 27 MW in 2012, 20 MW in 2016 and 18 MW in 2020*."

Based on the portfolio of projects and policy issues identified in the context of national development, the following technologies have been identified as having possible applications:

[4] Conducting Technology Needs Assessments for Climate Change (2010). United nations Development Programme 1 UN Plaza, New York, New York 10017, USA

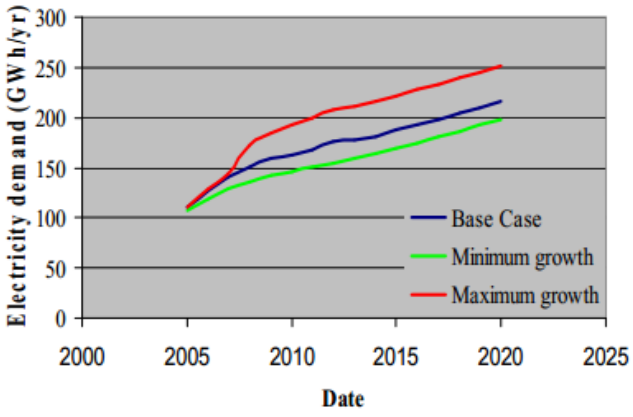
[5] Evelien K. Brederode and Kevin de Cuba. JUSTIFICATION AND PRE-FEASIBILITY STUDY OF AN ELECTRICAL INTERCONNECTION FOR ST. KITTS AND NEVIS Department of Sustainable Development Organization of American States. https://www.oas.org/DSD/reia/Documents/St.%20Kitts%20-%20RenewableEnergyProjectsandInter-connectionAssessment.pdf *retrieved February 21 2015*

Wind energy development

The commissioning of a 1.1 MW wind farm in Nevis in 2010 demonstrates the feasibility of wind power generation in the country. Further it has been identified[3] that interconnection between St. Kitts and Nevis (see Figures below) can provide St. Kitts with the forecasted demand deficit as Nevis can generate a surplus through wind and geothermal sources. Wind technology therefore remains a feasible and desirable option in meeting the electricity demands of St. Kitts and Nevis in the future. However, cost may prove to be a potential barrier and investment incentives can serve to attract investors in this regard.

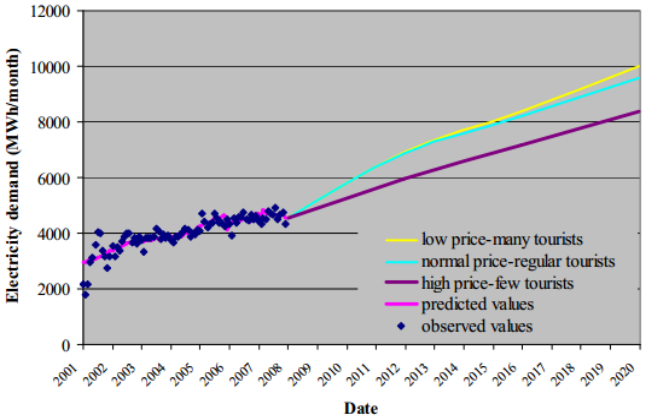
The Figures below illustrates forecasted electricity demand for both St. Kitts and Nevis.

Forecasted Annual Electricity Demand in St. Kitts[6]



[6] Stanley Consultants 2005 as cited in Evelien K. Brederode and Kevin de Cuba. JUSTIFICATION AND PRE-FEASIBILITY STUDY OF AN ELECTRICAL INTERCONNECTION FOR ST. KITTS AND NEVIS Department of Sustainable Development Organization of American States. https://www.oas.org/DSD/reia/Documents/St.%20Kitts%20-%20RenewableEnergyProjectsandInter-connectionAssessment.pdf *retrieved February 21 2015*

Forecasted Annual Electricity Demand in Nevis under Various Scenarios[7]



Geothermal Energy Development

Geothermal energy sources have proven to be feasible through studies conducted (see chapter on Mitigation and Abatement) in Nevis. As with wind energy, the full realisation of geothermal energy potential may face cost barriers. However, the policy and legislative framework has been established and therefore this technology, as with wind energy sources, is a feasible and desirable technology for mitigation.

Biomass Energy Development

As identified in the Mitigation and abatement chapter, this technology can be feasible once sugar production exceeds a critical threshold. A study in 2007[8] which examined the feasibility of biomass to energy of sugarcane using various technology choices, agricultural potential and socio-economic scenarios concluded that this technology is feasible but may be cost prohibitive. Additionally it was suggested that bioenergy may be better utilized for electricity generation than in the transportation sector. However, with the closure of the sugar cane industry in 2004, the

[7] Evelien K. Brederode and Kevin de Cuba. JUSTIFICATION AND PRE-FEASIBILITY STUDY OF AN ELECTRICAL INTERCONNECTION FOR ST. KITTS AND NEVIS Department of Sustainable Development Organization of American States. https://www.oas.org/DSD/reia/Documents/St.%20Kitts%20-%20RenewableEnergyProjectsandInter-connectionAssessment.pdf *retrieved February 21 2015*

[8] Background Discussion Paper on Bio-energy Potential For St. Kitts and Nevis. The General Secretariat of the Organization of American States (GS/OAS) and Energy and Security group (ESG) as part of the Global Sustainable Energy Islands Initiative (GSEII)

enabling environment may prove to be a critical barrier and various incentives, including financial, may be needed to provide the necessary impetus.

4.2 Adaptation

St. Kitts and Nevis as a small island developing state is particularly vulnerable to the adverse impacts of climate change on it various physical features (including natural and man-made) and their amenity values. In this regard, it has been identified that in the context of the impacts of climate change in the coming decades vulnerable sectors remain the coastal zone, water resources, human health, human settlement, agriculture and tourism.

Coastal Zone

St. Kitts and Nevis does not have a formal coastal zone policy, but such policy is implicit in the national development plans and policies. However, a draft St. Kitts and Nevis National Maritime Policy and Action Plan has been developed[9] that contextualises the policy in the wider sustainable development objectives of St. Kitts and Nevis. A policy analysis conducted in preparation for the Third International Conference on Small Island Developing States[10] identified coastal zone issues in the existing policy, legislative and regulatory framework. Additionally, a report in 2010[11] concluded that marine zoning (and therefore management) is consistent with the policies of the government of St. Kitts and Nevis in the context of climate change and its adverse impacts in this sector. Accordingly, it is recognised that planning comprehensive coastal zone management plans that take climate change into consideration is a critical first step in implementing adaptation strategies and on-the-ground measures. In this regard, an identified technology need has been identified[8] as conservation planning tools, which is soft technology, but which will enable planners and managers to make the correct choices in the face of a range of impacts from climate change.

Implementation of the National Maritime Policy and Action Plan identifies the need to, *inter alia*:

[9] Final Draft. National Maritime Policy and Action Plan. Department of Maritime Affairs. Ministry of Tourism and International Transport. Government of St. Kitts and Nevis. 2013.
http://www.stkittsnevisregistry.net/forms/skn%20nmp%20draft%2022%2001%2013%20version%204.0.pdf retrieved 21 February 2015

[10] THIRD INTERNATIONAL CONFERENCE ON SMALL ISLAND DEVELOPING STATES (SIDS) National Preparatory Process ST. KITTS AND NEVIS BACKGROUND REPORT Prepared by Island Planning Services. *website: https://sustainabledevelopment.un.org/content/documents/1129245SKN%20Final%20Draft%20National%20Report.pdf retrieved 21 February 2015.*

[11] Marine Zoning in Saint Kitts and Nevis A Path Towards Sustainable Management of Marine Resources Report by: Vera N. Agostini, Shawn W. Margles, Steven R. Schill, John E. Knowles, Ruth J. Blyther. USAID and The Nature Conservancy. *http://www.marineplanning.org/pdf/StKitts_Nevis_Full_Report.pdf retrieved 21 February 2015*

- Map existing and possible future uses of the marine environment by different activities
- Conduct an audit to ascertain existing availability of marine data
- Undertake a systematic analysis to quantify the value of the 'ocean economy' and the potential value of key marine resources/activities
- Improve co-operation in the collection, monitoring and disseminating of information, including the integration of local knowledge
- Promote the integration of existing marine databases, management of marine data and use of historical information
- Facilitate/support research to increase understanding of the marine environment, its natural processes and cultural marine
- Develop a marine research strategy that identifies and prioritises information needs and the cooperative mechanisms for acquiring accessing and disseminating information
- Ensure that adaptation in coastal and marine areas is taken into account in the implementation of this policy

The comprehensive implementation of the draft National Maritime Policy would therefore require meticulous planning and the necessary tools for such planning is indispensible. In this regard, soft technologies would be required in the immediate to short term in order to facilitate planning and implementation. Such soft technologies would include:

- data collection and management know-how and modeling
- Mapping technologies such as GIS and associated software and management systems
- database management know how
- vulnerability assessment modeling software for the coastal zone

Water Resources

The National Conservation and Environmental Protection Act, No. 5 1987 provides the overarching legislative framework that addresses, *inter alia*, water resource management issues. Specifically, it is keyed to the following areas in the context of Agenda 21 and sustainable development objectives[12]:

• Agriculture and rural development,

[12] THIRD INTERNATIONAL CONFERENCE ON SMALL ISLAND DEVELOPING STATES (SIDS) National Preparatory Process ST. KITTS AND NEVIS BACKGROUND REPORT Prepared by Island Planning Services. *website: https://sustainabledevelopment.un.org/content/documents/1129245SKN%20Final%20Draft%20National%20Report.pdf retrieved 21 February 2015.*

• Environmental protection,

• Water resources management,

• Land use planning,

• Climate change adaptation, and

• Biological diversity conservation.

A Food and Agriculture Oragnisation (FAO) study for St. Kitts and Nevis in respect of water issues[13] indicates that both islands suffer water shortages in the dry season and has also identified that the Department of Agriculture, St. Kitts, considers the lack of water for supplementary irrigation in the dry season as the major constraint to achieving one of its primary goals: year round production of selected vegetables. Technologies that are consistent with these issues are therefore relevant and include:

- Domestic water conservation technologies such as water efficient faucets, toilets and showerheads;

- Irrigation technologies including sprinkler systems and drip irrigation;

- Rainwater harvesting;

- Technologies for soil and water conservation (also applicable to the agricultural sector) such as storage ponds;

Human Health

A recent assessment by the Pan American health Organisation (PAHO)[14] indicates that *"health conditions in Saint Kitts and Nevis are favorable to human development, and that....the country has embraced the primary health care approach, with its strategies of community participation, health promotion, and intersectoral collaboration, and has ensured that health care is accessible and affordable to the population, which has barrier-free access to government services spanning*

[13] http://www.fao.org/nr/water/aquastat/countries_regions/st_kitts_nev/print1.stm retrieved 21 February 2015
[14] Health in the Americas, 2012 Edition: Country Volume. Pan American Health Organization, 2012. http://www.paho.org/saludenlasamericas/index.php?gid=145&option=com_docman&task=doc_view retrieved 21 February 2015

the range from prevention to palliation. The country has had much success in addressing the health-related Millennium Development Goals."

However, with the likelihood of increasing vector borne diseases due to increasing environmental conditions brought about by climate change, containment and management of such outbreaks would become increasingly important. In this regard, the employment and deployment of relevant technological measures would become necessary. Such would include:

- Deployment of fogging machines for vector spraying;

- Use of insecticide-treated nets;

- Integrated vector management systems (IVM) (process for managing vector populations in such a way as to reduce or interrupt transmission of disease).

Since dengue is endemic to St. Kitts and Nevis, the need for suitable modeling of disease outbreaks in light of climate change would be extremely important. Accordingly, modeling software and associated know how would be need in the immediate to short term.

Human Settlements

Given that human settlement trends in St. Kitts and Nevis follow one of settlement very close to the coastlines[15], technology issues related to human settlement adaptation approaches can be covered in those related to coastal zone management and under the draft National Maritime Policy

Agriculture

The closure of the sugar production industry in St. Kitts and Nevis has resulted in an impetus for the Government to increase non-sugar agricultural production[16], and led to the subsequent development of the St. Kitts Agricultural Development Strategy (ADS), which stresses an integrated production and marketing system which is expected to contribute significantly to the economic diversification programme[17]. In keeping with this development policy, relevant

[15] Initial National Communication of St. Kitts and Nevis to the United Nations Framework Convention on Climate Change. http://unfccc.int/resource/docs/natc/kitnc1.pdf retrieved 21 February 2015
[16] http://www.caricom.org/jsp/community/donor_conference_agriculture/agri_profile_st_kitts.jsp retrieved 21 February 2015
[17] THIRD INTERNATIONAL CONFERENCE ON SMALL ISLAND DEVELOPING STATES (SIDS) National Preparatory Process ST. KITTS AND NEVIS BACKGROUND REPORT Prepared by Island Planning Services. *website: https://sustainabledevelopment.un.org/content/documents/1129245SKN%20Final%20Draft%20National%20Report.pdf retrieved 21 February 2015.*

technological needs will be consistent with those identified in the TNA relating to the adverse impacts of climate change, and which would readily find nexus and synergy with those related to water resources and fisheries management namely:

- Early warning systems for forecasting of wet and dry periods;
- Adoption of drought-resistant cultivars;
- Geographical Information Systems (GIS);
- Change of sowing and harvesting periods;
- Pesticide application technologies and practices;
- Integrated Pest Management (IPM) systems and practices;
- Soil management technologies and practices;
- Aquaculture and mariculture technologies.

Tourism

Since the tourism sector is a product of, and benefits from other sectors, climate change impacts on these sectors will inevitably impact on the overall tourism product. Technology needs in these sectors would therefore be relevant to managing the tourism sector in the face of climate change impacts. In this regard, the table illustrating the nexuses and the respective technologies identified are referenced.